

Wendy van Duivenvoorde

FOREWORD BY JEREMY GREEN

Dutch East India Company Shipbuilding

THE ARCHAEOLOGICAL STUDY OF
BATAVIA AND OTHER SEVENTEENTH-
CENTURY VOC SHIPS



DUTCH EAST INDIA COMPANY SHIPBUILDING

ED RACHAL FOUNDATION

NAUTICAL ARCHAEOLOGY

SERIES



In association with the
Institute of Nautical
Archaeology



and the Center for Maritime
Archaeology and Conservation



Dutch East India Company Shipbuilding

THE ARCHAEOLOGICAL STUDY OF
BATAVIA AND OTHER SEVENTEENTH-
CENTURY VOC SHIPS

Wendy van Duivenvoorde

FOREWORD BY JEREMY GREEN

TEXAS A&M UNIVERSITY PRESS *College Station*

Copyright © 2015 by Wendy van Duivenvoorde
Manufactured in the United States of America
All rights reserved
First edition

This paper meets the requirements of ANSI/NISO Z39.48-1992 (Permanence of Paper).
Binding materials have been chosen for durability.



Library of Congress Cataloging-in-Publication Data

Van Duivenvoorde, Wendy, 1974–, author.

Dutch East India Company shipbuilding: the archaeological study of Batavia and other
seventeenth-century VOC ships / Wendy van Duivenvoorde; foreword by Jeremy Green.—First edition.
pages cm—(Ed Rachal Foundation nautical archaeology series)

Includes bibliographical references and index.

ISBN 978-1-62349-179-6 (printed case: alk. paper)—ISBN 978-1-62349-231-1 (ebook) 1. Batavia (Ship)
2. Nederlandsche Oost-Indische Compagnie—History. 3. Indiamen—Netherlands. 4. Shipbuilding—
Netherlands—History—17th century. 5. Hulls (Naval architecture)—Design and construction. 6.
Shipwrecks—Australia—Western Australia. 7. Underwater archaeology—Australia—Western Australia.
I. Title. II. Series: Ed Rachal Foundation nautical archaeological series.

VM393.I64V36 2015

623.82209492'09032—dc23

2014019853

To my parents,

Jacobus Johannes van Duivenvoorde

and

Anna Klazina Maria van Duivenvoorde-Knopjes

CONTENTS

Foreword, by Jeremy Green *ix*

Acknowledgments *xi*

Legend for Timber Drawings *xiii*

- 1 Introduction *1*
 - 2 From Carvel Construction to VOC Shipbuilding *8*
 - 3 Site Formation, Excavation, and Reconstruction *40*
 - 4 Hull Study and Description *73*
 - 5 The Archaeology of Dutch Oceangoing Ships *143*
 - 6 Double-Hull Planking and Sheathing *186*
 - 7 Timber Used in the Construction of *Batavia* *206*
 - 8 Analysis of *Batavia*'s Hull and Construction *224*
 - 9 Conclusion *235*
- Appendix A: VOC Ship Construction Charters *241*
- Appendix B: Catalog of *Batavia* Hull Remains *253*
- Appendix C: Terminology for Dendrochronological Research,
by Elsemieke Hanraets *265*
- Notes *267*
- Bibliography *291*
- Index *303*



FOREWORD

It is with great pleasure that I write the foreword for this book. Having spent most of the 1970s excavating and researching the *Batavia* shipwreck, and then finally overseeing reconstruction of the recovered surviving portion of the ship's hull after a lengthy conservation process, I was aware that the details of hull construction had not been properly documented. At the Fifth International Symposium on Boat and Ship Archaeology in Amsterdam in 1988, I presented a paper on the planking-first construction of *Batavia*'s hull. This came as a bit of a shock to many of the conference participants, as it was generally accepted that planking-first, or shell-first, construction had died out by the seventeenth century. At that time, few seventeenth-century ships had been excavated archaeologically, and no other hull structure from a Verenigde Oostindische Compagnie (VOC) ship had been excavated. Subsequent examination of contemporary paintings and illustrations revealed that this system was widely used, at least in the Netherlands, and particularly by the VOC. However, the thought of documenting the *Batavia* hull in great detail was for me quite daunting. What I needed was a researcher well versed in nautical archaeology and wooden ship construction who was also capable of studying Dutch archival material.

In June 2002, I ran into Wendy van Duivenvoorde at the Bodrum airport in Turkey. We were both on our way to the International Symposium and Workshop on Underwater Archaeology, hosted by Turkey's Ministry of Culture and the Institute of Nautical Archaeology (INA) in Bodrum and at nearby Pabuç Burnu. Wendy and I had worked together the previous summer at Tektaş Burnu, Turkey, on the final season of INA's Classical shipwreck excavation and later in Galle, Sri Lanka, on the VOC *Avondster* project. Our concurrent arrival in Bodrum, from opposite sides of the world, was truly serendipitous, and I was not about to waste this opportune encounter. As we walked together through the airport lobby, chatting casually and catching up on what we had been up to since we last saw each other, I asked Wendy about her long-term plans. When she replied that she was somewhat frustrated in finding a ship-related research project, I wasted no time in making a pitch. Here was a Dutch maritime archaeologist eager for a research project, and I had just the thing. We were still making our way through customs when I told her of the *Batavia* hull remains that needed studying, as well as related materials from three other VOC shipwrecks in the Western Australian (WA) Museum. I offered her not only the material for study but also a position at the museum. We collected our luggage and headed off to the conference, all the while discussing possible research plans, specifics about the archaeological material, living in Fremantle, and sundry other matters.

Upon her return to Texas A&M University in College Station, Texas, Wendy developed and submitted a formal research proposal for the project. After receiving approval, she spent the following two years conducting historical and archival research but also visited the museum on two occasions to begin the recording and sampling program. In 2006, Wendy finally relocated to Fremantle and started work as an assistant curator in the WA Museum's Department of Maritime Archaeology. It took another two years and count-

less hours spent scanning excavation registers and photographic film, crawling over and recording the reassembled hull structure in the Shipwreck Galleries and hundreds of other disarticulated hull fragments in storage, and poring through hundreds of archival documents and scholarly publications to complete the study. The outcome of Wendy's work, presented in these pages, has been outstanding. But it did not end there. Wendy has continued to investigate Western Australia's Dutch shipwrecks during her three years as a museum curator and, since 2011, as a lecturer in maritime archaeology at Flinders University. She remains committed to the ongoing research of *Batavia* and the Dutch presence in WA and continues to work closely with the WA Museum and the Department of Maritime Archaeology.

Once, many years ago, after having completed the *Batavia* excavation, the director of the WA Museum asked me, "When do you think all this [conservation, research, reconstruction, curating] will be finished?" My reply was, "It's a never-ending story; it will probably go on forever." This book is another step in that story.

—*Jeremy Green*

ACKNOWLEDGMENTS

This book is based on research conducted in the Netherlands and Australia from 2002 to 2008. This work is the result of the combined efforts of all those who were involved, supported my research, and made it possible for me to publish the results. Numerous institutions generously funded my education at Texas A&M University, research, and lengthy stays in the Netherlands and Australia. I would like to thank the Prins Bernhard Cultuurfonds, NACEE Fulbright, Nuffic Talentprogramma, Catharine van Tussenbroek Fonds, Stichting Fundatie Vrijvrouwe van Renswoude, Studiefonds Ketel I, Jo Kolk Stichting, Hendrik Muller's Vaderlandsch Fonds, Stichting Trireme, Allard Pierson Stichting, Marine Technology Society, and the Women Divers Hall of Fame for financial support. The last two years of research and writing were supported in various ways by Texas A&M University: a Marion C. Cook Fellowship from the Nautical Archaeology Program; an AUF Liberal Arts Meritorious Graduate Student Tuition Fellowship and College of Liberal Arts Dissertation Research Award from the College of Liberal Arts; and a Research and Presentation Grant from the Association of Former Students and the Office of Graduate Studies. For these honors awarded by the university, I am most grateful.

In addition, I would like to thank the Nautical Archaeology Program faculty for providing me with numerous plane tickets to conduct research and present my research at conferences overseas. I am especially grateful to Filipe Vieira Castro, Kevin Crisman, and Cemal Pulak for accommodating and supporting my research and sharing their experiences and knowledge.

I thank Jeremy Green, head of the Maritime Archaeology Department of the Western Australian Museum, for inviting me to study the archaeological hull remains of *Batavia* and for publication. Without these research opportunities, it would have been impossible to study the *Batavia* hull remains. The museum staff, Jon Carpenter, Susan Cox, Ian Godfrey, Kalle Kasi, Ian MacLeod, Tracey Miller, Maggie Myers, Richenda Prall, Jennifer Rodrigues, Vicki Richards, Corioli Souter, and Myra Stanbury have been extremely hospitable and helpful.

At the Rijksmuseum of Amsterdam, Ab Hoving provided me with a mutual interest, valuable dialogue, and constructive criticism whenever I asked for it. Academia needs more scholars—inquisitive, sharing, and empirical—like him. Undoubtedly, Ab has been for many years the most prominent and unsurpassed researcher in the field of Dutch nautical history. Much of the research presented in this book is based or elaborates on his pioneering work on Dutch shipbuilding practices from the sixteenth century onward.

Also special thanks to Bill Leonard, curator of the Maritime History Department of the Western Australian Museum, for providing me with practical discussion and insight and for sharing his passion for shipbuilding with me.

My sincere appreciation is offered to Lucas Brouwer, Fik Meijer, and Harald Kruithof for their financial assistance and caring encouragement. In addition, I would like to thank Jessica Berry, Jan Bill, Genevieve Brown, Cor Emke, Christian Lemée, Jerzy Gawronski, Herman Ketting, Fred Hocker, Simon Jellema, Thijs Maarleveld, Martijn Manders,

Aleydis van de Moortel, Rasika Muthucumarana, Wil Nagelkerken, Ruud Paesi, Robert Parthesius, Jessica Reynolds, Thomas Wazny, and Joke Wittebrood for helping me advance my research and/or sharing their expertise and knowledge.

At BIAAX Consult, Henk van Haaster, Caroline Vermeeren, and Pauline van Rijn conducted the analysis and identification of hair and wood samples of the *Batavia* hull. At the Institute of Archaeology (Botanical Laboratories), Tel Aviv University, Nili Liphshitz identified and studied wood samples of the *Batavia* and *Vergulde Draak* hulls. I must acknowledge Elsemieke Hanraets and Esther Jansma at RING, who performed the dendrochronological investigation of the *Batavia* hull planking. At the University of Minnesota, St. Paul, Robert Blanchette of the Department of Plant Pathology studied possible brown-rot fungus observed on some of the *Batavia* timbers. Thank you all for your time and support.

At the Laboratory for Isotope Geology, Swedish Museum of Natural History, Kjell Billström helped me with the lead isotope analyses of the *Batavia* copper sample. Special thanks also to Sophie Stos Gale and Martin Whitehouse for helping me get in contact with Kjell and for their professional guidance.

At the Western Australian Museum, I would like to thank Geoff Kimpton, whose path crossed mine only a few times and who was retired by the time I started my research. Geoff spent nearly 11 years reconstructing the *Batavia*'s hull for museum display and did an outstanding job. He deserves much more credit than he got for doing so. His efforts cleared the way for my research, which would otherwise have taken untold years to accomplish. The accuracy with which he reassembled the ship's hull after conservation is an impressive accomplishment that continuously astonished me while I was doing my own research. What Sisyphus work.




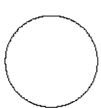

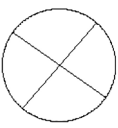

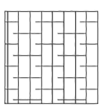

Patrick Baker greatly contributed to making an accurate record of the *Batavia* shipwreck and facilitated this research more than anyone else. He photographed every *Batavia* timber in the field and underwater. His recording skills, as well as his memories of the *Batavia* excavation, have proven to be superb. Thank you, Pat, for your photographs, support, input, listening ears, and heartwarming smile.

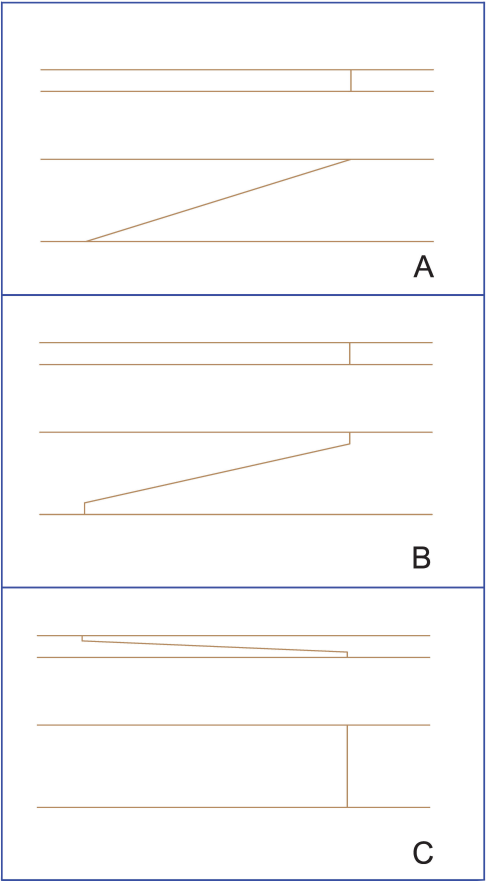
André Murteira was so kind to share a Portuguese soldier's account dating to 1607/1608 pertaining to information on Dutch shipbuilding. Five others facilitated my work for this book: Barbara Consolini, Adriaan de Jong, Tristan Mostert, Vibeke Roeper, and Lous Zuiderbaan, all trained in reading seventeenth-century Dutch script and willing to check references, transcribe archival resources, and/or look up entries for me in the Nationaal Archief in The Hague.

I also want to thank Hanneke Jansen for her assistance in sampling and recording the *Batavia* hull remains, her near-endless scanning of archival records, and her patience in spite of demanding hours, many of which were overtime, working in the Western Australian Museum.

I am very grateful to Kroum Batchvarov, Celeste Jordan, LeeAnne Gordon, Michael McCarthy, Alistair Paterson, and Mark Polzer for their time and energy to improve and review this work. Finally, I would like thank James Delgado for his assistance in getting this work published. I owe you one.

LEGEND FOR TIMBER DRAWINGS

	Wooden nail plug
	Empty spike/nail hole
	Metal spike/nail hole
	Empty fastening hole
	Metal bolt shank
	Wooden treenail
	Damaged, nonoriginal surface
	Brown or surface soft rot
	Crack in timber



TERMINOLOGY FOR THE SCARF JOINTS DESCRIBED

Throughout this book, the different scarf joints utilized in *Batavia's* construction will follow the terminology provided by J. Richard Steffy, *Wooden Ship Building and the Interpretation of Shipwrecks*, 292: A, diagonal scarf; B, flat scarf; and C, vertical flat scarf. The author acknowledges the many other terms used for different styles of scarfs.

**DUTCH
EAST INDIA
COMPANY
SHIPBUILDING**

INTRODUCTION

On its maiden voyage to the Indies, the Dutch East Indiaman *Batavia* sank on Morning Reef in the Houtman Abrolhos off the western coast of Australia in the early-morning hours of 4 June 1629. The new ship of the Dutch United East India Company (Verenigde Oostindische Compagnie, or VOC) had set sail eight months earlier on 29 October 1628.¹ The 600-ton ship left Texel in the Dutch Republic with 341 people onboard, bound for Batavia, modern-day Jakarta, in Indonesia.² It was the first of three *retourschepen* (return-voyage ships) to be named *Batavia* over the nearly 200-year history of the VOC's existence from 1602 to 1795.³

In addition to its flagship, *Batavia*, the 1628 "Fair Fleet" was made up of six ships, five of them named after Dutch cities: the flutes *Assendelft*, like *Batavia* newly built, and *Zaandam* (each 500 tons); the ships *Buren* (200 tons), *Dordrecht* (500 tons), *'s-Gravenhage* (300 tons); and the yacht *Kleine David* (100 tons).⁴ The Fair Fleet, named after the traditional September fair, was typical for the 1630s. It was a third fleet added to the annual East India trade. The other two fleets set sail in December/January and April/May and were known as the Christmas and Easter Fleets, respectively. The Fair Fleet set sail in September or early October and, ideally, would arrive in the Indies in time for a favorable connection with the Asian trade network.⁵ With the expansion of the company's Asian trading network into India, China, and Japan in the early seventeenth century, it had become increasingly important to arrive in Asia before the end of the summer monsoons. Monsoon season ran from June through September, and the monsoons facilitated sailing from Batavia to India in the east and to China and Japan in the north. The third fleet was added because the Christmas Fleet was not always able to arrive in Batavia before the end of the monsoon season; in this case, the VOC missed out on a portion of its trade.⁶

Batavia's 1628 Fair Fleet should be considered an experimental venture designed to capitalize on a favorable connection to the intra-Asiatic trade network. The addition of this particular fleet was largely supported by the Amsterdam Chamber,⁷ for which all the ships sailed, except *Buren* (Enkhuizen Chamber) and *Kleine David* (Hoorn Chamber).⁸

Batavia's fleet was not blessed by particularly good fortune. Only *'s-Gravenhage* returned to the Netherlands.⁹ Three vessels, *Buren* and the two flutes, were destined to stay in the Indies from the onset. The fate of the others was less fortunate: *Batavia* was wrecked in the Houtman Abrolhos Archipelago before reaching its final destination; *Dordrecht* was burned on its homebound voyage in April 1630 at 4°33' N; and *Kleine David* was destroyed by fire along the Coromandel Coast, India, on 11 February 1630. The *'s-Gravenhage* met a similar fate during its second voyage and was burned by the Portuguese off Goa on 4 January 1634.¹⁰

Upon setting sail on 28 October 1628, *Batavia* immediately ran aground off Texel. Fortunately, the ship refloated and continued its voyage one day later. It was only the first

of a series of misfortunes that befell *Batavia* and its fleet. The next delay was probably at the roadstead of Duins (the Downs) on the southeastern coast of England. In general, VOC ships had to wait here for the right wind that would carry them through the English Channel. It could take weeks for this wind to come up, which may have happened for *Batavia*'s fleet; the ship *Galiasse*, which set sail from Holland at the end of December, overtook the ships before they made the Cape of Good Hope.¹¹

Since 1616, all VOC ships had been instructed to sail south from the Cape of Good Hope and catch the strong westerly winds, the Roaring Forties, between latitudes 40° S and 50° S. This ensured a faster and safer route to the Indies, as it expedited the sailing time by several months and circumvented Portuguese territory in Asia.¹² The new nautical highway, the so-called Brouwer Route, was first encountered by Hendrik Brouwer in 1610–11 and made mandatory five years later.¹³ After Dutch ships had caught the Roaring Forties in their sails, they followed this nautical passage 1,000 miles (7,407 km) east and then turned north with the Southeast Trade Winds that would lead them directly into the Sunda Strait.¹⁴

An unpleasant problem of the Brouwer Route was the inability to determine longitude. Miscalculations, coupled with the strength of the trade winds, often caused the ships to miss their turn to the north. Having passed this junction, Dutch ships like *Batavia* ended up along the western coast of Australia. The frequency of this occurrence played a major role in Dutch reconnaissance of the Australian coast and led to the European discovery and exploration of this vast continent.

The difficult sailing conditions in Western Australia's waters included treacherous reefs, strong currents, unpredictable winds, and shallow waters, the latter occasionally in conjunction with a rough and inaccessible shore. If these navigational hazards are taken into account, it is surprising that only a few VOC ships were lost in these waters. These shipwrecks include *Batavia* (1629), *Vergulde Draak* (1656), *Zuiddorp* (1712), and *Zeewijk* (1727).

Batavia was, however, not the first European ship to sink in Australian waters. When the English took notice of the Brouwer Route, they followed the Dutch example and first sailed it in 1620–21; their initial voyage was considered a great accomplishment. During the second English attempt to use the new route, their ship *Trial* sailed too far to the east and missed its turn to the Sunda Strait.¹⁵ It was wrecked in 1622 on a reef of rock in the Indian Ocean, which now carries its name, off the northwestern outer edge of the Monte Bello Islands along the Australian coast. *Trial* became Australia's oldest known shipwreck, and the English consequently avoided the Brouwer Route for the next two decades.

It must also be noted that VOC ships like *Batavia*, sailing too far to the east with the Roaring Forties, were not the first to travel through Australian waters. The first recorded presence of the Dutch in Australian territory dates to 1606, when skipper Willem Jansz and upper-merchant Jan Lodewijksz van Rosingeyn sailed their ship *Duifje* into the Gulf of Carpentaria off Australia's Northern Territory. This Dutch expedition discovered New Guinea and other island groups and predated Cook's exploration of the Australian continent in 1770 by 164 years.¹⁶

Batavia was the first Dutch ship to sink in Australian waters when it struck Morning Reef. About 300 among the crew and passengers survived and made it safely to the unin-

habited, barren Abrolhos Islands. Commander-in-Chief Francisco Pelsaert left the wreck site in one of the ship's boats with a group of 48 people, including 2 women and 1 child, to seek help in Batavia. By the time Pelsaert returned over three months later, there were fewer survivors left on the islands.¹⁷ The tragedy that befell *Batavia's* stranded company makes the famous mutiny on the *Bounty* seem trivial by comparison.

Various Dutch authors from the seventeenth century have related the grisly events in which 125 men, women, and children were deliberately drowned, were strangled, had their throats cut, or were brutally hacked to death by a group of men who had gathered around instigator and acting commander Jeronimus Cornelisz.¹⁸ One month after the wrecking, the organized killing began in secret at night. It was not long, however, before everyone on the islands knew what was going on, but most had become too weak to fight off the killers. One group of survivors sent off to find fresh water on West Wallabi Island did manage to fight back. When help finally arrived from Batavia, they managed to warn Pelsaert before his ship anchored at Beacon Island. The group that had camped out on West Wallabi and the remaining people on Beacon Island were brought safely to their final destination while the Dutch authorities prosecuted, convicted, and executed the men who had formed the eager death squad.

Together with the many victims of the harrowing massacre, *Batavia's* wreckage was left behind in the Houtman Abrolhos. Little mention was made of the shipwreck site for more than 200 years. In 1840, while surveying the Western Australian coast, the crew of *Beagle* observed a shipwreck at the southern end of the Abrolhos Group of islands and assumed it was the wreck of *Batavia*. In the 1950s, historian Henrietta Drake-Brockman argued that the wreck could not be situated at the southern end of the Abrolhos Group of islands but must lie near the Wallabi Group. According to Drake-Brockman, the ship should have been wrecked here for the simple reason that only on these islands are found marsupials, more specifically tammar-wallabies, and water holes with drinkable water.¹⁹ She believed that the shipwreck was located near Noon Reef. Her theory was based on thorough historical research, which was published in a pivotal work on *Batavia's* shipwrecking that included a full translation of Francisco Pelsaert's journal by E. D. Drok.²⁰ With Drake-Brockman's work in hand, journalist Hugh Edwards organized the first expedition to find the shipwreck around Beacon Island in the Wallabi Group in 1960, but they were unable to determine the shipwreck's location.

On 4 June 1963, Abrolhos fisherman Dave Johnson showed a group of divers from Geraldton, including the brothers Max and Graham Cramer and Greg Allen, a large anchor on Morning Reef, about 2 km southeast of Beacon Island, that he had often observed from his boat while setting lobster pots. The three divers entered the water and found *Batavia's* wreckage in shallow waters about 3 to 7 m deep. The shipwreck site covered an area about 50 m long and 15 m wide and was littered with cannon and anchors. This discovery showed that the shipwreck was not situated on Noon Reef but slightly more to the east on Morning Reef.

In 1972, the Dutch and Australian governments signed the bilateral agreement between the Netherlands and Australia concerning Old Dutch Shipwrecks, in which the Dutch state transferred its ownership of VOC shipwrecks in Australian waters to Australia. The wreck of the *Batavia* and its associated land features have become one of the most prominent aspects of Australia's archaeological heritage. Although they are protected

under the Historic Shipwrecks Act of 1976, their significance was officially recognized only in 2006 when they were finally placed on the National Heritage List of the Australian government.

After its discovery, *Batavia*'s wreckage was excavated between 1973 and 1976 by a team of archaeologists from the Maritime Archaeology Department of the Western Australian Museum under the direction of Jeremy Green and was revisited in 1980.²¹ Thousands of artifacts that were once part of the ship's cargo, equipment, or personal belongings of the crew, passengers, and soldiers were uncovered from beneath the sand and coral concretions.²² At the southern end of the wreck site, part of the ship's port-side stern section was preserved below the wreck's debris. The wooden hull was recorded and raised from the seabed in the three excavation seasons between 1973 and 1975. The Western Australian Museum is the authority responsible for *Batavia*'s artifacts and hull remains.

Since the shipwreck's discovery and excavation, many scholars, students, and laymen have published books and articles on *Batavia*'s history and its archaeological materials. The study of *Batavia*'s construction and wooden hull, however, had not been finalized and published. Jeremy Green, the archaeologist responsible for the excavation and conservation of *Batavia*, invited the author to undertake a comprehensive study of *Batavia*'s hull in the summer of 2002, and the study of *Batavia*'s hull timbers commenced in 2003.

The hull timbers raised from the seabed weigh roughly 20 tons and represent approximately 3.5% of the original hull. They comprise the port-side transom and part of the stern port quarter of the vessel, including the sternpost, a fashion piece, transom timbers, 5 transom knees, 21 planking strakes—including 3 wales—12 strakes of ceiling planking plus 1 shelf clamp, remnants of 46 frames, 1 gun port lid, 2 deck beams, and 2 hanging and 1 lodging deck knees. *Batavia*'s structural timbers are made of oak. A significant part of the hull has been reassembled and is displayed in the Western Australian Museum—Shipwreck Galleries. Many timbers, however, including the ship's pine hull sheathing, inner floor of the ceiling planking, and frame wedges, remain in storage.

To date, *Batavia* represents the only excavated remains of an early seventeenth-century Dutch East Indiaman that have been raised and conserved in a way that permits detailed study. This is of great significance since there are no construction plans, lines drawings, or building records for any East Indiamen of this period. We know that the ships built for the VOC in the early seventeenth century were typically large merchantmen that rarely exceeded 500 tons, whereas most Portuguese Indiamen were two to three times that size. The smaller size of the Dutch ships was a direct result of the shallow waterways, flats, tidal currents, and sandbanks in the Netherlands.²³ Since the establishment of the VOC, the first multinational corporation, in 1602, the company employed ships that were specifically designed and constructed for the lengthy voyage to Asia and back. They had to be large enough to provide sufficient hold space for their cargoes, as well as the ship's equipment and crew's food and water necessary to maintain the ship at sea for several months. Even though smaller than their Portuguese counterparts, they were sturdily built to stand up to hard service in stormy seas and last for six or more round-trip voyages. They were also outfitted with heavy armament to repel attack by pirates, enemy warships, or other human dangers along the way.²⁴

Early seventeenth-century Dutch Indiamen resembled a ship type that the Spanish and Portuguese would call *galleon*. They had a square, flat stern; usually two fully planked decks that carried artillery; and aft of the main mast a quarterdeck and a poop deck.²⁵

Characteristic fore- and aftercastles were well integrated into the ships' hulls. The vessels carried three masts, with square sails on the fore- and mainmasts and a lateen on the mizzen. *Batavia* also had a mizzen topmast, main topmast, main topgallant, fore topmast, fore topgallant, spritsail, and sprit topsail with square sails.

The shape, size, and rigging of Dutch Indiamen evolved from the late sixteenth to the eighteenth centuries. In spite of the ships' size and specific characteristics, construction details, particularly in the early seventeenth century, were poorly recorded or not recorded at all. Their contribution to Dutch wealth and power, however, inspired many artists to paint or draw them. Consequently, the study of Dutch East Indiamen dating to the early seventeenth century has been based on iconographic evidence, archival records, and contemporary documents on shipbuilding. In fact, a replica of *Batavia* built in the Netherlands in the 1980s was based entirely on secondary sources. Nevertheless, construction details of Dutch East Indiamen remain largely unknown. Although the wreck sites of at least 47 Dutch East Indiamen have been found and identified, *Batavia*'s wooden hull is the only one dating to the early seventeenth century from which all hull timbers have been raised and conserved in a way that permits detailed study. All the other known remains from this period have either been salvaged by treasure hunters, looted by fishermen and sport divers, or subject to archaeological investigations that included in situ observation or recording only, that is, not the raising of the hull timbers.

This book is the result of five years of study aimed at reconstructing the hull of *Batavia* as found on the shipwreck site using data retrieved from the archaeological remains, interpreted in the light of VOC archives, ships' journals, and Dutch texts on shipbuilding of this period. The foundation for this study, however, was laid by the many archaeologists, conservators, and volunteers who have worked with the ship's timbers since their excavation in the 1970s.

The study of a ship cannot be considered complete if its context is not understood. Therefore, this study goes beyond the basic historical and socioeconomic aspects and emphasizes technological parameters and thought processes active in the production of the hull-related elements under study. It attempts to develop a more systematic and analytical approach to the formulation, analysis, and evaluation of research questions relating to *Batavia*. This includes aspects of metallurgy, casting techniques, and wood-working for shipbuilding in order to relate the study of the ship to what is known about the people who built and sailed it. It focuses on the technology available at the time of its construction.

Chapter 2 provides a brief introduction to the history of Holland, its shipbuilding efforts, the technological development that directly influenced its shipbuilding industry, its cultural and socioeconomic climate, and the Dutch India trade in the early seventeenth century. It delineates the origin of the Indiamen in the context of Dutch shipbuilding tradition and discusses construction sequence, emphasizing the techniques used at local shipyards and their peculiarities. This chapter also discusses important VOC shipbuilding charters and texts and the origin of construction features seen in Dutch ships designed and built for long-distance voyages. It provides parallels to shipbuilding practices of other European countries, such as Spain, Portugal, England, and France, which seem to have influenced Dutch shipbuilding. This chapter provides a basic background and sets the stage for understanding *Batavia*'s construction.

Chapter 3 includes the archaeological circumstances in which *Batavia*'s shipwreck

was found, starting with the site's location, the wrecking event, and the site's formation. Aspects of the site and its excavation methodology are discussed as they relate to the hull study. Moreover, the methodology for recording and drawing the *Batavia's* hull timbers is evaluated. Keeping past study efforts in mind, a detailed discussion of the research method used for this particular study is delineated. It also outlines the reassembly of the hull for museum display and the method used to take *Batavia's* lines from the reassembled structure.

Chapter 4 focuses on *Batavia's* construction history and overall appearance. The hull remains are described in detail, with discussions of each component and the size and shape of its scantlings, fasteners, and waterproofing. Dimensional units in this book are metric unless the text concerns one of the local Dutch systems from the sixteenth, seventeenth, or eighteenth centuries. If the Amsterdam unit of measurement is referenced, the equivalent metric dimension is given in parentheses. Dozens of local units of measurement were in use in post-medieval Holland. If the measurement system used in a particular archival document is ambiguous or unknown, no equivalent metric dimension is provided and the units are stated simply as feet/thumbs.

Chapter 5 compares *Batavia's* hull remains with archaeological finds from similar ships of the late sixteenth and early seventeenth centuries. It provides an overview of all archaeological examples known to date and introduces hull remains of shipwrecks that have not been published before, such as those of the VOC ship *Vergulde Draak* (1656). It also looks at the complications encountered when trying to compare the archaeological material from this period to VOC ships from the late seventeenth century.

The ship names in this book follow the spelling provided by Bruijn, Gaastra, and Schöffer's *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, a three-volume publication that offers a uniform spelling for numerous variants given in historic sources. In the seventeenth century, especially, the names of ships were not used in a consistent manner and often had additional words added to their names, such as *large* or *new*. Bruijn, Gaastra, and Schöffer's index of all VOC return voyages to the Indies allows for easy checking of all long-distance voyages made by a specific ship and its details.²⁶

Chapter 6 discusses late sixteenth- and early seventeenth-century shipbuilding as found in contemporaneous documentation, specifically, ships' journals and VOC shipbuilding charters and the late seventeenth-century manuscripts of Nicolaes Witsen and Cornelis Van IJk. These historic texts are compared to the archaeological data in the previous chapter and are assessed in the light of what is learned from the archaeological evidence. This chapter specifically focuses on the use of double-hull planking, pine sheathing, other sheathing methods, and caulking of ships in service of the long-distance trading companies and the VOC. The last section looks at the measures taken by the VOC, in particular, to maintain its ships at home and abroad.

Chapter 7 delineates the analysis of the wood used in *Batavia's* construction based on the identification of the species of wood used for its timbers and their dendrochronological study. It presents the available historic documentation of the Dutch wood trade and discusses the ensuing limitations, outlining the extent of trade, the provenance of timber used for shipbuilding in the early seventeenth century, the use of Baltic oak for hull planking, drying or seasoning of timber, and the methods of processing timber for shipbuilding, construction, and artwork. Based on the dendrochronology of *Batavia's* timber, a hypothesis is put forward relating to the timber used for shipbuilding (particularly by

the VOC), the VOC's requirements for the quality of ship timber, and the possible influence of its policy on the deforestation of the regions along the Vistula River in Poland.

Chapter 8 interprets the data presented in the previous chapters and offers a proposed reconstruction of the *Batavia*. This chapter begins with a critical discussion of *Batavia*'s hull shape and moves into the discussion of its timbers. A lines drawing depicts the preserved hull shape. My goal is to show that the construction of Dutch Indiamen was different from that of other contemporary merchantmen and warships. Chapter 9 summarizes the assumptions and conclusions of this study and critiques its methodology, stressing its most important strengths and weaknesses.

My primary objective is to create a better understanding of Dutch shipbuilding practices in the late sixteenth and early seventeenth centuries, in particular for ships designed and constructed to sail long distances over the world's oceans. This study focuses on *Batavia*'s construction sequence and assembly details based upon the existing hull remains and supplemented by contemporary archival material. The ship's features are compared to other historic and archaeological data, and the hull remains are presented in the form of lines drawings showing *Batavia*'s preserved shape. Key elements of the original hull, for example, the bow and keel, no longer exist, and therefore any reconstruction of the ship is partly conjectural. The reconstruction and presentation of *Batavia*'s hull remains should therefore be looked upon as an educated guess and a working hypothesis, respectively, rather than a final reconstruction and arrangement, even where data seem to fit into the theoretical framework or calculations. Hopefully, this work will set an example for other archaeologists studying the remains of Dutch Indiamen and ships dating to the sixteenth and seventeenth centuries and provide their studies with a theoretical framework for research.

2

FROM CARVEL CONSTRUCTION TO VOC SHIPBUILDING

Dutch shipbuilding practices in the late sixteenth and early seventeenth centuries were the result of local technological development and Holland's cultural and socioeconomic climate. At this time, the Dutch commenced their own trade with Asia and set sail beyond European waters. For the first time, they had to design and build ships for long-distance voyages. Dutch ships in this period were the result of both local and foreign traditions; shipbuilding practices of countries such as Spain, Portugal, England, and France seem to have influenced Dutch shipbuilding. VOC shipbuilding charters have survived from the late sixteenth and early seventeenth centuries to aid our understanding of Dutch East India ships. This chapter provides a background—to set the stage as it were—in which to place and understand *Batavia*'s construction.

FROM LAPSTRAKE TO CARVEL PLANKING IN BOTTOM-BASED SHIPBUILDING

The cog builders of northwestern Europe, in particular the Dutch, were the first to incorporate flush-laid planks above the ships' bottoms into their shipbuilding during the late fifteenth century. The tradition was imported from the Mediterranean via Portugal, Spain, Bordeaux, and Brittany, although the Dutch did not immediately adopt the frame-based construction technique and design methods of the Mediterranean vessels.¹ They first applied the carvel-planked technology to large vessels. Dutch records from the southern inland boundaries of the Netherlands mention *karveels* that were commissioned by Philips de Goede around 1439 and built by Portuguese shipwrights, probably in a Mediterranean design method.² Carvel-planked technology was not evenly implemented in the entire Lowlands and, therefore, not immediately adopted in the northern Netherlands.³ Not until 1459, a full two decades later, did Breton shipwrights begin building a carvel-planked ship in the town of Zierikzee, followed thereafter by the construction of similar ships in the town of Hoorn in 1460 in the northern region of the Netherlands.⁴ The earliest archaeological evidence of a carvel-planked boat from the Netherlands is a fishing vessel dating to 1570 excavated in the IJsselmeerpolders.⁵ Carvel-plank technology slowly became more common, particularly for oceangoing vessels. Lapstrake planking, on the other hand, did not completely disappear, and its use continued for the construction of small craft. A contemporary example of a large vessel with lapstrake planking is seen in the archaeologically excavated U34 ship, which dates to 1530. It was excavated in eastern Flevoland, Netherlands, in 1969. Its preserved hull remains measure 30 m in length, 9.5 m in width, and 5.4 m in height.⁶ The study of this wreck's hull is still ongoing.⁷

Many Dutch shipbuilders continued to assemble ships using their traditional bottom-based method to build carvel-planked vessels. The bottom of a ship was assembled in a shell-based method, in which the planks were held together with temporary wooden

cleats until the frame floors and first futtocks were inserted. The temporary cleats were removed as the ship's framework was installed, after which the side planking was fastened to the frames in the new plank-on-frame method. This bottom-based construction method appears to have developed independently from shell-based or frame-based construction and represents an entirely different shipbuilding philosophy.⁸ Developed over many centuries, this construction method combined features of shell-first and frame-first construction but was not a specific application of attributes from those methods. It must be noted that this was *not* an intermediate phase between the shell-based and frame-based methods, as suggested in the past.⁹ The bottom-based method is typical for northwestern Europe and had been used there at least since Roman times. Due to their grounding in this technique, Dutch shipwrights had no immediate need to develop more scientific design methods in shipbuilding, and the bottom-based method allowed them to increase their technological lead over their French and English colleagues in the sixteenth and early seventeenth centuries. According to Hocker, the Dutch skipped much of the experimenting that is normally associated with the adoption of a new technology but could instead take immediate advantage of the economic benefits of carvel planking. Hocker concluded that it was more cost effective to build carvel-planked ships, as this reduced the amount of labor and iron fasteners needed (long double-clenched iron nails were used extensively to fasten the lapstraked planks of clinker-built ships). It did not, however, reduce the amount of timber used to build a ship, for despite the elimination of overlap between the planking, the wood saved by flush-laid planking is negligible. Shipbuilders compensated for the decreased structural strength of the ship's skin or shell by increasing the number of frames used. Archaeological evidence from the *Almere Cog* (early fifteenth century) and the *B71 karveel* (late sixteenth century) demonstrates that frame room and space narrowed considerably at this time. An important consequence of the Dutch head start was a significant amount of technical achievement. One important advantage of combining carvel planking with the bottom-based construction method was that the Dutch did not have to make major modifications to their construction method since they were already using the carvel-construction approach in assembling the ship's bottom.¹⁰ It was, therefore, not a completely new technology but an adjustment of existing technology that allowed the Dutch to take the lead.

SHIPBUILDING AND WOOD USAGE

The Dutch became the foremost shipbuilders in northern Europe in the sixteenth and seventeenth centuries and exported both finished vessels and labor to other countries. By 1640, approximately 1,000 ships were built annually in the Lowlands. Nearly 320,000 m³ of oak were used in the Dutch shipyards for seagoing ships alone. This equals 2,500 hectares of forest used per year and does not include the wood used to build ships for inland shipping.¹¹

A significant portion of these ships were exported to foreign markets, such as Sweden, France, England, Russia, Denmark, the Italian states, Hamburg, Bremen, and the Baltic region. In 1628, for example, three large ships were built in the shipyards of Saerдам (modern-day Zaandam) for Cardinal de Richelieu, the chief minister of King Louis XIII of France, each ship weighing about 1,000 to 1,200 tons.¹²

The Lowlands did not have sufficient natural resources to provide the necessary timbers used for shipbuilding. Indeed, after the eleventh century, the Dutch could no longer

TABLE 2-1. Provenance of timber coming into the Netherlands in *lasten*

Geographic region	1650	%	1750	%
Norway	130,000	75	38,000	22
Baltic Sea	27,000	16	80,000	47
Rhine	9,500	6	47,000	27
Emden, Germany, to Esbjerg, Denmark	5,500	3	6,000	4
Total	172,000	100	171,000	100

Source: Porsius, "Hout en schepen," 11.

Note: One *last* (plural: *lasten*) is approximately 2 metric tons.

provide the necessary quantity of wood from local resources as a result of a steady rise in population and consequent demand for building materials and thus had to import timber.¹³ The first evidence for long-distance timber transport into the Netherlands comes from the town of Dorestad, where wooden barrels from the Mainz area in Germany were found in the construction of wells dating to the ninth century.¹⁴ Timber became one of the most significant import commodities used for the construction of buildings and ships. From the early medieval period onward, the Lowlands and other western European countries conserved their own resources by importing oak from the Baltic Sea region.¹⁵ By 1650, the majority of imported softwoods, fir (*Picea abies*) and pine (*Pinus sylvestris*), came from Norway and the Baltic Sea region; most of the oak used in shipbuilding was obtained from the Weser and Elbe area in northern Germany (table 2-1).¹⁶ Raw timber was imported by ships and distributed across the Lowlands through a trade network of towns such as Deventer, Dordrecht, Venlo, and Keulen.¹⁷

The wood market of Deventer, for example, supplied mainly Amsterdam and the towns situated on the western coast of the Zuiderzee with uncut oak, whereas the market of Dordrecht was the main supplier of wood for the shipyards of the Saer region (modern-day Zaanstreek) and the southern Dutch towns.¹⁸

THE INVENTION OF THE SAWMILL

Hocker noted that Dutch ships "were seaworthy, capacious, and inexpensive, partly due to superior management of the supply of imported timber."¹⁹ The rapid production of Dutch ships, however, can also be attributed to something other than superior management of timber supply and applying carvel planking in a bottom-based construction method. A noteworthy technological advantage was obtained by the invention of a wind-driven sawmill by Cornelis Corneliszoon from Uitgeest in 1594. This new type of mill made it possible to saw large quantities of planks and beams in a shorter time and with less labor than previously required. Consequently, sawmill production of timber in the Lowlands increased 3,000% over hand-sawn timber production. The mills were capable of sawing 60 beams in 4 to 5 workdays instead of the 120 days required for the same number of beams sawn by hand.²⁰ The enormous growth of Dutch shipbuilding at the beginning of the seventeenth century must have been significantly influenced by this innovation.²¹



FIGURE 2-1. Map of Holland showing Amsterdam (red dot), Zaandam (yellow dot), the Zaan region (yellow outline), and the later VOC Chambers of Delft, Enkhuizen, Rotterdam, and Delft (blue dots). The Chamber of Zeeland (Middelburg) is situated outside this map at the lower left. Map after I. P. Saenredam, Amsterdam University Library (UvA), University Museum, 1589.

Flourishing trade in the Lowlands in the late sixteenth century increased the demand for timber to build houses, waterworks, and more ships. This demand is best illustrated by the pay raises given to the large group of hand sawyers employed in Amsterdam in 1590.²² Woodcutting guilds in Amsterdam suffered competition from their colleagues in the northern Zaan area, the rural district directly north of Amsterdam, who were able to produce the same amount of timber for two-thirds the price due to cheaper living conditions, the absence of guilds and price regulations, and lack of quality control (fig. 2-1).

While wind-driven mills facilitated the thriving Zaandam industry in the early seventeenth century, no major developments of a similar nature followed in Amsterdam

until 1630. The first small, primitive sawmill was built in 1598 by Adriaen Corneliszoon on a float outside Amsterdam's Saint Anthonis Gate.²³ He was granted a monopoly for such a mill for 20 years. In 1607, when another entrepreneur requested permission to build a second small mill to saw planks and sheathing on a float between the Amstel Bridge and the bridge to the timber market, the city council turned down the request.²⁴ Consequently, Amsterdam's second sawmill was not constructed until 1619.²⁵ However, efforts to construct wind-driven mills before 1630 were insignificant in comparison with the expansion of timber mills in the Zaan region.

By 1630, Amsterdam did not have a single sawmill inside its city walls, mainly due to the resistance of the hand sawyers' guild.²⁶ A contributing factor was the lack of space in the city for the construction of such mills. At this time, the Zaan region had 53 working sawmills. The hand sawyers of Amsterdam tried to ensure their income according to an agreement in 1620 with two mill owners from Zaandam who had each built a sawmill directly outside Amsterdam. The mill owners would accept contracts to saw only pine, keeping the privilege to saw oak entirely to the hand sawyers. However, a year later an edict was enacted in Amsterdam to boycott beams and planks processed elsewhere, as such timber kept making its way into the city (specifically, from sawmills in the Zaan region). It was also prohibited to transport uncut timber from Amsterdam to the surrounding areas.²⁷ According to Vibeke Kingma, these regulations were probably not too strictly enforced, as only a few cases of offense are known,²⁸ but the hand sawyers' guild could not sustain itself and eventually dissolved in 1627.

Consequently, Amsterdam tried to meet local demand for wood by constructing its own sawmills from 1630 onward.²⁹ A collection of Amsterdam's most prominent timber merchants, along with several carpenters, shipwrights, and coopers, raised 40,000 guilders and, on 5 January 1630, applied for a patent to establish the Sawmill Development Company. This patent was endorsed six months later, on 28 June, and the company was granted sole authority to construct new wind-driven sawmills in the city. Sixteen windmills were consequently constructed outside the Raampoort and Regulierspoort city gates. The starting capital raised to found the Sawmill Development Company and construct wind-driven sawmills was 74,000 guilders.³⁰ The most important customers of the wind-driven sawmills were undoubtedly the VOC, the West India Company (WIC), and the Amsterdam Admiralty.³¹ The Sawmill Development Company was disbanded in 1639 and its 16 sawmills divided in two groups among its shareholders. Both parties agreed to sell sufficient sawn timber to Amsterdam's citizens, the city, Admiralty, VOC, and WIC.³² The number of sawmills continued to expand throughout the seventeenth century. By 1645, the city of Amsterdam had 45 wind-driven sawmills, and in 1660, the first VOC-owned sawmill came into operation.³³

The invention of the sawmill must have played an important role in the rapid production of Dutch ships during the late sixteenth and early seventeenth centuries, perhaps more so than either the Dutch fusion of carvel-planked and bottom-based construction methods or Dutch efficiency in the wood trade. Meanwhile, English and French shipwrights had developed different naval architectural techniques as a result of the influence of Mediterranean builders. By the late seventeenth century, English and French shipwrights began to outpace the Dutch in ship construction after having taken their time to learn the design methods of the Mediterranean builders and experiment with new design methods.³⁴

DUTCH SHIPBUILDING FOR THE INTRA-EUROPEAN AND INTER-CONTINENTAL TRADE

In the sixteenth century, the socioeconomic, technological, and political climates in the Netherlands resulted in dynamic developments in Dutch shipbuilding. Dutch shipwrights began altering existing vessels, building new ships with increased cargo capacities, and constructing merchantmen for long-distance trade. The lengthening of existing merchant vessels is a prime example of these innovations.³⁵ This practice was a direct result of the enormous economic growth and urgent need for more cargo capacity. The hulls of lengthened ships, the so-called *verlangers*, were cut in half amidships, after which an extra section was added.³⁶ Contemporaneous Dutch texts indicate that specific reference to the word *verlanger* was made only for the short period of time between 1587 and 1619.³⁷ Although closely related to the development of the flute ship, the term *verlanger* does not specifically refer to a type of ship but rather to the process of lengthening a vessel. Yachts, boats, carvel ships, *busses*, and *boeiers* are all known to have been lengthened.³⁸

New types of ships were also constructed. The flute ship was launched, a type developed in the Netherlands over the last decades of the sixteenth century to meet the need for ships for the Dutch Baltic trade. The flute's hull shape was designed to evade Danish Sound tolls without reducing cargo capacity.³⁹ Pieter Jansz Liorne is said to have invented the flute ship in 1595, but ship scholar André Wegener Sleeswyk has recently demonstrated that Liorne should not be credited as the "inventor" of this particular ship type. Liorne was not a shipbuilder; he was the mayor of the town of Hoorn who invested in the construction of this ship type, thereby carrying the financial risk and sponsoring its development.⁴⁰

The seventeenth-century flute had a narrow top and upper stern with a round tuck and typically three wales girdling the sides of the ship below the level of its helm port. This hull form, pear shaped in cross section, is also referred to as turret built or kettle bottomed (fig. 2-2). The characteristically narrow main deck and poop contrasted sharply with the bulky cargo hold below; the maximum breadth of the ship lay below the waterline. Flutes had an average cargo carrying capacity of approximately 200 tons around 1600, which increased during the course of the seventeenth century to 360 tons.⁴¹ Flutes had a shallow draft and a relatively high length-to-beam ratio of 4:1 or more, although this was also characteristic for other ship types. *Batavia*, for example, being an Indiaman, had a similar length-to-beam ratio of 4.4:1.

The Dutch managed to construct flutes at a much lower price than that of merchant vessels of other European countries. Violet Barbour demonstrated that a flute built in the Netherlands cost 800 pounds sterling, whereas a similar ship would cost 1,300 pounds sterling in England. Additional examples have shown that the price of similar vessels could exceed the Dutch price by more than half the cost.⁴² According to Richard Unger, the Dutch shipyards managed to keep the price down by constructing flutes and other oceangoing ships primarily in the Zaan region. Here, taxes and the cost of land were lower. Standardization and the establishment of a large-scale shipbuilding industry also kept the cost lower.⁴³ Other European nations, however, also had rural areas with similar conditions and industrial standardization. Dutch shipbuilders and merchants were not limited by royal or patron interference when deciding how to build their ships, which certainly made them more efficient.⁴⁴ It must be noted that the Dutch had to import all



FIGURE 2-2. Flute ship with narrow upper deck and three wales below the helm port. Engraving by Abraham Allard, 1650, National Maritime Museum Amsterdam (A.0149-562).

timber used in shipbuilding, which did not necessarily make the construction of a ship cheaper. Dutch flutes simply had lower construction costs because their timber was mechanically sawn in wind-driven sawmills. Wegener Sleeswyk adds that the construction of round tuck sterns cost less than square tuck sterns, seen in other contemporaneous oceangoing ship types, as they required less timber. He also adds that they were easier to assemble.⁴⁵ Most shipwrights will probably disagree with the last point, as round tuck

sterns are actually harder to construct because strong twisting of timbers is required and they are harder to frame.⁴⁶

Although the construction cost of Dutch flutes was relatively low, the ships may not have been cheaper in the long run, as they probably had a shorter life expectancy than ships built by other European maritime powers.⁴⁷ Dutch shipbuilders are known to have used pine in the construction of some of their ships, particularly flutes. Pine was cheaper and lighter than oak and, although not as durable, was still cost-effective for certain trades.⁴⁸ The mid-seventeenth century BZN 10 shipwreck found in the Dutch waters of the Waddenzee is an archaeological example of a large vessel—its hull remains are 40 m in length—even though archaeologists do not necessarily agree that it has a Dutch origin. The BZN 10 ship has substantial amounts of pine in its frames, ceiling, internal structure, and some of the hull planking near the stern.⁴⁹

Generally, flutes had tall masts and short yards, permitting easier handling. Sir Walter Raleigh mentioned in the early seventeenth century that Dutch flutes could sail with a crew of 7 men and a boy, whereas English merchant ships required 20 men.⁵⁰ Wegener Sleswyk demonstrated that the smaller crews on Dutch flutes were also a result of other circumstances. The Dutch were, for example, not bound by guilds and regulations like the Hanse cities were, and sailing from the Netherlands to the Baltic Sea was considered relatively safe, thus requiring fewer crew members.⁵¹ The crews were also paid low wages. The “family business” nature of Dutch seafaring culture kept wages low at a time when there was a significant shortage of able seamen.⁵² Regardless, the flute was a runaway success, though it did not help the Dutch gain control of maritime commerce because the ship type did not become established until Holland’s hegemony was already secure.

In this period, the Dutch were also challenged by the need to contract, for the first time, large merchant ships for intercontinental seafaring. Among the European powers, the Dutch had entered the world’s oceans last, more than a century after the Spanish, Portuguese, and French and a few decades after the English. In the early 1590s, the Dutch started sailing in waters beyond their European trade network to acquire direct access to the colonial commodities of Asia and extend their trade realm. The first two Dutch attempts to sail to the Indies, in 1594 and 1595, were under the command of Jan Huygen van Linschoten, who tried to sail via the Open Polar Sea, a hypothetical northern route along the North Pole.⁵³ The voyages were not successful. A third and last attempt to open up this route to the Indies was made one year later, in 1596, under the command of Willem Barents and Jacob van Heemskerck.⁵⁴

During the attempts to open up the route through the Open Polar Sea, another Dutch expedition had set sail in 1595 following the Portuguese route around the Cape of Good Hope.⁵⁵ This expedition was organized by a consortium of nine Dutch businessmen. Five ships set sail under command of Cornelis Houtman, and it took almost three years for the fleet to return with spices, such as nutmeg, mace, and black pepper. This first expedition was not a commercial success—the sale of its return cargo covered only the expedition’s cost.⁵⁶ One ship, the 260-ton *Amsterdam*, and more than two-thirds of the seamen did not return to the Netherlands. Regardless of the losses and lack of commercial profit, the expedition demonstrated that the Dutch were able to sail to Asia themselves and that Portugal could no longer exclude newcomers from the Asian trade.⁵⁷ On their first expedition, the Dutch went straight to the Indonesian islands to obtain the desired commodities, thereby circumventing the major Portuguese entrepôts.

By 1601, some 15 fleets totaling 65 ships had set sail to the Indies.⁵⁸ Most impressive was undoubtedly Jacob Corneliszoon van Neck, who returned with four fully laden ships within 15 months (1 May 1598 to 19 July 1599).⁵⁹ Successful expeditions, such as Van Neck's, made profits of more than 400%. By 1601, the Dutch volume of trade had become much greater than that of the Portuguese. The expeditions to the Indies were organized by the so-called *voorcompagnieën*, or joint-stock companies, from different towns and regions in the Netherlands. The lack of coordination in this booming business swiftly entangled the *voorcompagnieën* in a competition that drove up the prices of spices at the source. To combine trade efforts, the VOC was founded after lengthy negotiations with the Dutch government.

The company's organizational structure comprised six chambers represented by the port cities Amsterdam, Hoorn, Enkhuizen, Rotterdam, Delft, and Middelburg (the latter is also referred to as Zeeland). The delegates of these chambers formed a board of directors and convened as the Heren XVII (Gentlemen XVII). They were selected from the directors of each chamber, who were the most prominent or highest class of shareholders, and their meetings two or three times per year could last several weeks. The Gentlemen XVII consisted of eight delegates from the Chamber of Amsterdam, four from the Chamber of Zeeland, and one from each of the other chambers. The seventeenth delegate would come in turn from the Chamber of Zeeland or the five small chambers to prevent Amsterdam from dominating the decision making. The VOC was given extraordinary independence from the Dutch government and was granted a complete monopoly in the east, with the right to appoint governors, raise armies, build fortresses, and make treaties with foreign potentates.⁶⁰

From the late 1590s, the Dutch, for the first time, had to build heavier ships specially designed and constructed for the lengthy voyage to Batavia and back. Although an established trading post since 1610, the town of Jakarta became the VOC's purposely established Asian headquarters—it was renamed Batavia in 1619. It became the main center within a trading network to which most outbound ships from Holland sailed and from which most homebound ships set sail (with the exception of some ships that sailed directly to China, Bengal, or Ceylon). It was also the transshipping point and staple market for all interport trade of the VOC in Asia.

Until the end of the sixteenth century, Dutch ships destined for long-distance journeys were much smaller than those of the Spanish, Portuguese, and English.⁶¹ The ships were also of shallower draft, which made them better suited to the peculiarities of Dutch waterways. In general, the number of ships over 200 tons was negligible in 1599.⁶² An exception, however, were the ships sailing for the joint-stock companies between 1595 and 1601. Their weight varied between 50 and 900 tons, averaging around 350 tons.⁶³ The Portuguese, on the other hand, built ships weighing up to 1,600 tons. A Dutch report, dating to 1604, lists a Portuguese fleet of carracks in the Indies: the admiral's ship of 1,600 tons, the vice-admiral's ship of 1,200 tons, four carracks of 800 tons, and two of 600 tons.⁶⁴ At the time, the largest VOC ships equaled the smallest Portuguese ships in size.

The Dutch certainly had the ability to build large ships in the early seventeenth century, of which *Hollandse Tuin* is an example (fig. 2-3). This four-masted ship was the 1,000-ton showpiece of the Amsterdam Admiralty but was offered for service in the long-distance trade and military operations because it proved unmanageable in Dutch waters. It sailed to Brazil in a flotilla of five ships under the command of Paulus van Caerden in 1603. In



FIGURE 2-3. Warships sailing into the IJ upon return from Brazil in 1605, including *Hollandse Tuin* of the Amsterdam Admiralty (center). Painting by Hendrik Cornelisz Vroom, 1605–40, Rijksmuseum Amsterdam (SK-A-1361).

the early seventeenth century, four-masted ships like *Hollandse Tuin* entered the Dutch seafaring scene briefly, although they were not common.⁶⁵

From its founding, the VOC followed the advice of the Dutch government and tended to use fewer, larger ships that were sufficiently manned and armed to trade, attack Portuguese interests, and protect prospective allies in trade. In the early years of its existence, the VOC used ships of different sizes. The larger vessels, with a cargo capacity of 300 tons and more, were referred to as ships, whereas smaller ships were referred to as yachts (in the late sixteenth and early seventeenth centuries they were sometimes also referred to as *pinassen*, *pinnaces*, or *pinances*).⁶⁶ All ships were similar in appearance; they had a gun deck with cannon, a transom stern with a square tuck, and three masts with a full ship rig.⁶⁷ Small yachts could be rowed if needed, but they were not specially designed for this type of propulsion.⁶⁸ Some ships were built to sail directly to the Indies and back, while others often remained in the Indies for some period of time. The VOC later referred to the large Indiaman as a *retourschip* (plural, *retourschepen*), or return-voyage ship. The name originates from the cargoes (*retouren*, or returns) brought back to the Netherlands from Asia in the seventeenth century.⁶⁹ Although cargoes were called *retouren* in the early seventeenth century, the name “return-voyage ship” emerged only after 1620.⁷⁰ It does not refer to a particular type of ship, as ships, yachts, and flutes were all return-voyage ships if destined to make the round-trip to Asia. Prior to 1620, all return-voyage ships were simply referred to as India ships. Although the VOC did not specifically send large Indiamen to Asia to stay in the Indies and become local workhorses of the company, these ships were occasionally employed for the intra-Asiatic trade before returning to the Netherlands or deployed in Asia at the end of their working lives. Many yachts, on

the other hand, were specifically employed by the VOC to stay in the Indies and become permanent additions to the company's fleet overseas. Over the VOC's life span hundreds of yachts were permanently stationed in the Indies.⁷¹ During the seventeenth century the term "yacht" included larger ships, and those with cargo-carrying capacities of 300 to 500 tons were more often called yachts from the late seventeenth century onward.⁷²

When Pieter Both, the first governor-general of the Dutch East Indies, implemented a permanent structure for the VOC in Asia in 1610, the company's management strategy was to use large Indiamen for the lengthy return voyages and employ a permanent fleet of yachts in Asia.⁷³ The VOC was keen to implement the policy to reduce the risk of losing these valuable freight carriers in Asian waters. This policy was not easily executed, however, because of the lack of an established fleet and infrastructure within Asia. It was finally put into practice after the founding of Batavia as the VOC's permanent headquarters in Asia in 1619.⁷⁴ After about 1614, other types of ships built for specific purposes, such as flutes, frigates, and warships, became more common and were added to diversify the VOC's permanent fleet.⁷⁵

From the commencement of Dutch long-distance voyages in 1594, a new and different type of ship had to be designed and constructed specifically for the lengthy voyage to Asia and back. Such ships were not commonly available and necessitated in-house developments from VOC shipyards. Know-how from other countries was combined with new innovations to produce the Dutch Indiaman. The result was a vessel custom-made for the East Indies route, much like the *verlangers* and flutes had been designed and developed specifically for the European trade. The development and improvement of the Dutch Indiamen remained an ongoing process throughout the VOC's existence.

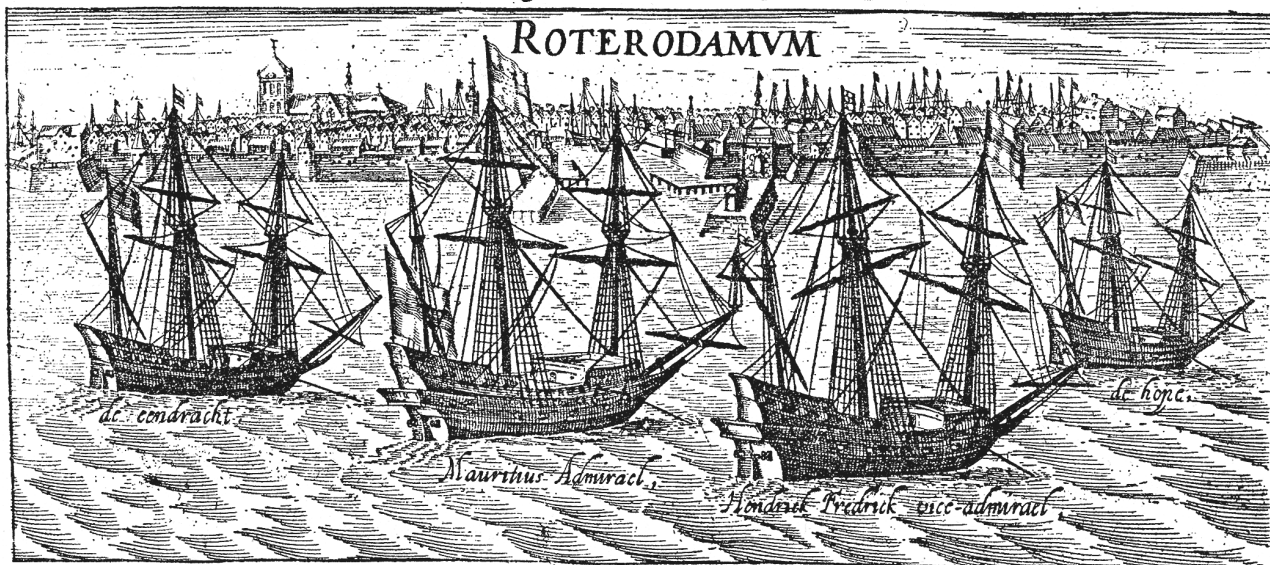
The early seventeenth-century Indiamen and yachts, which resembled a galleon, had a square, flat transom stern and, usually, two full decks, a quarterdeck, forecastle deck, and a poop deck aft of the main mast.⁷⁶ Characteristic fore- and aftercastles were well integrated into the ships' hulls. The vessels carried three masts, with square sails on the fore- and mainmasts and a lateen sail on the mizzen mast.

In the late sixteenth century new construction features were introduced, presumably from Iberian shipyards, possibly via England. The flat transom, for example, became prevalent in the construction of warships, Indiamen, and yachts, as illustrated on well-known maps of the period. On the 1544 Anthoniszoon map, only a few ships are shown with such a stern configuration. Nearly 50 years later, only one ship with a round tuck is represented among numerous vessels with flat transoms on the Piet Bas map, dating to 1597.⁷⁷

Karl Marquardt, in the journal *The Great Circle*, argued that the Dutch did not use flat transom sterns for small yachts around 1600,⁷⁸ although his article is irrelevant because crucial evidence from iconographic and written sources was omitted.⁷⁹ First, numerous illustrations of yachts showing square tucks can be found in the ship journals of the Dutch long-distance trading companies and the VOC from 1595 onward. The ships depicted in these journals are definitely small yachts since they are specifically designated as such; additionally, their names and tonnages are given. The drawings of the two small yachts *Zwaan* (80 tons) and *Griffioen* (172 tons), for example, clearly show that they were constructed with a flat transom stern or square tuck.⁸⁰ The yachts were used in the first two Dutch attempts to sail to China through the Open Polar Sea in 1594 and 1595. Another example includes all the drawings of the yacht *Hoop* (50 tons), which circumnavigated the

Beschryvinghe bande Voyagie om den geheelen Werelt Cloot/ghedaen door Olivier van Noort van Vtrecht, Generael over vier Schepen/te weten: Mauritius als Admirael/Hendrick Frederick Vice-Admirael/de Eendracht, middelgaders de Hope, op hebbende slaven 248. man/om te zeplen door de Straete Magellanes, te handelen langs de Custen van Cica, Chili en Peru, om den gantschen Aerden Cloot/ende door de Molucques wederom thups te comen. Te zepl gegaen van Rotterdam den tweeden July 1598. Ende den Generael met het Schip Mauritius is alleen weder ghekeert in Augusto Anno 1601.

Daer in dat vertelt wort zyne wonderlijcke avontueren, ende vreemdigheden hem bejagent, by hem ghesien, ende die hem vvedervaren zijn, Met vele Copere Caerten ende Figuren afgebeeld, by hemlieden niculicx gheteckent ende mede ghebracht.



Tot Rotterdam.
By Ian van Waesberghen, ende by Cornelis Claessz tot Amstelredam, op't Water
int Schryfboeck, Anno 1602.

FIGURE 2-4. Three Indiamen and one yacht (right) with a flat transom and a square tuck. Illustration by Jan W. IJzerman, *De Reis om de Wereld door Olivier van Noort*, title page.

world with Olivier van Noort from 1598 to 1601 (fig. 2-4).⁸¹ Furthermore, the earliest VOC construction charter (1603) or contract for 160-ton yachts refers specifically to the size of the wing transom, which shows that yachts were built with a flat transom.

The design, appearance, size, and rigging of Dutch Indiamen changed dramatically from the late sixteenth to the eighteenth centuries. In spite of the grandeur of the ships, which inspired many artists to paint or draw them, few details of their construction were recorded, and they remain largely unknown to this day. Consequently, the study of Dutch East Indiamen dating to the early seventeenth century has been based primarily on iconographic evidence, archival records, and contemporary documents on shipbuilding.

WRITTEN SOURCES AND VOC SHIPBUILDING CHARTERS

The best-known Dutch manuscripts on naval architecture date to the late seventeenth century. The oldest, *Aeloude en Hedendaagsche Scheeps-bouw en Bestier* (Ancient and contemporary shipbuilding and management), was published in 1671 by Nicolaes

Witsen. Twenty-six years later, Cornelis van IJk published his manuscript on Dutch shipbuilding, *De Nederlandsche Scheepsbouw Konst Opengesteld* (The art of Dutch shipbuilding exposed). In his shipbuilding manual, Witsen discussed the principles of Dutch bottom-based construction, which originated in northwestern Europe, whereas the work of Van IJk expounded on the frame-based construction being used in the Rotterdam shipyards by 1697. Unlike their European colleagues, who focused mainly on methods of hull design, both Witsen and Van IJk described the construction sequence of Dutch shipbuilding employed in the seventeenth century, which exemplifies a practice that seems typical of Dutch shipyards.⁸²

The works of Witsen and Van IJk are considered the first and foremost Dutch manuscripts on shipbuilding. Late sixteenth- and early seventeenth-century sources are, however, available and are perhaps more applicable to *Batavia*'s construction. The documents that survive from this period, in particular those of the VOC and Dutch Admiralties, and contemporary ship journals frequently refer to shipbuilding or provide construction details. The earliest Dutch shipbuilding charter found to date comes from the archives in Zeeland and dates to 1593.⁸³ It was written for the construction of a *pinasse* 85.5 ft long (roughly 25.5 m, depending on the local Dutch foot measure used).⁸⁴ From the late sixteenth century onward, ships were built according to charters in which the main purpose and dimensions were defined. These charters were basically used as instructions in which the VOC and other large establishments, such as the West India Company and Admiralties, laid down the standardized guidelines for the construction of their ships.

It is no simple matter to get an overall understanding of the construction of large oceangoing vessels built by the *voorcompagnieën* and the VOC. The VOC counselor and historian Pieter van Dam devoted many pages to the company's ships and their construction in his multivolume description of the United East India Company. His work is valuable but does not provide a clear and comprehensive insight for the modern-day audience.⁸⁵ The shipbuilding charters published by Van Dam are ambiguous and also contain minor transcription errors that, in the past, undoubtedly further confused those trying to interpret and understand the texts. The most detailed VOC shipbuilding charters from the first half of the seventeenth century, dating from 1603 to 1653, have been transcribed directly from the archives and are translated into English for this study in appendix A.

In the early seventeenth century, the basis of the VOC's shipbuilding policy was laid down by trial and error in the construction of ships and influenced by the advice of experienced shipwrights, captains, VOC officials in Asia, and other informed sources. It is known, for example, that Pieter Jansz Liorne provided technical advice to the VOC. The Amsterdam shipbuilder Jan Rijcksen played an important role in the development of the VOC's Indiamen and yachts. Born in 1560, he owned his own shipyard at the end of the sixteenth century and became the director of the VOC's Amsterdam shipyard in the 1620s.⁸⁶ The VOC shipbuilding charters were updated from time to time to cater to the changing demands and conditions. Technical decisions resulting from these updates were made by men with extensive experience in shipbuilding, such as Rijcksen and Liorne.

The VOC charters demonstrate that the ships and yachts were strong vessels with two full decks. The ships were mainly built of oak. The earliest charters show that even the planking of the lower, or main, and upper decks was made of oak, whereas in 1653, the planks of the upper deck were made of pine. The quarterdeck, forecastle deck, and poop deck were made of pine with oak waterways from the early seventeenth century onward.

Each VOC ship was inspected in its last stage of construction by a committee of experts from the combined VOC chambers to ensure that the current charter was followed. Such inspection had been routine since 1616.⁸⁷

Although the shipbuilding charters provided rigid guidelines for shipwrights in the shipyards of all VOC chambers, they were not always followed scrupulously. In 1627 and 1628, for example, the Chambers of Zeeland and Amsterdam were caught building their large ships with a height of approximately 14 Amsterdam ft (3.96 m) below the lower or main deck instead of the prescribed 12.5 Amsterdam ft (3.54 m), for which only the Chamber of Zeeland was reprimanded.⁸⁸ The inspection committee must have concluded, however, that VOC ships needed more height in the hold, as the change was included as an adjustment to the later 1628 charters for Amsterdam and Zeeland. The VOC master shipwrights were responsible for the final product and were not permitted to take any liberties with the prescribed shipbuilding charters, but the bottom-based construction method sometimes required or allowed for changes to be implemented. Flexibility is inherent in this construction method, but the VOC tried to restrain any diversions from its prescribed charters. Master shipwrights, such as Rijcksen, had to swear under oath not to deviate from the charters and were threatened with removal from their posts for any leniency.⁸⁹ In December 1631, for example, a new charter was read and handed over to Rijcksen during a meeting of the Gentlemen XVII. He accepted it under oath and promised to follow it “as much as possible.”⁹⁰ The chambers were also known to tamper with the charters in order to carry more cargo back from Asia. The fines for not adhering to the charters became heavier over time.⁹¹ The delegates of the chambers were held personally responsible for violations of the shipbuilding charters. In 1632, for example, each chamber was threatened with a fine of 1,000 Flemish pounds for violating ship construction charters; the fine was to be given as alms to the poor.⁹²

Although overall dimensions for the ships were regulated, construction details were left to the preferences and local traditions practiced by each VOC chamber shipyard. The Chambers of Amsterdam and Enkhuizen were, for example, highly praised for the use of closely set filling nails.⁹³ This policy could result in curious local designs, such as in 1605, when the Amsterdam Chamber decided to outfit its ships without forecastles and quarterdecks.⁹⁴

NAVAL ARCHITECTURE IN THE SEVENTEENTH CENTURY

The late sixteenth- and seventeenth-century ships built according to a bottom-based tradition were not predesigned on paper. Detailed information on shipbuilding was not written down, probably to safeguard the secrets of the trade; if it were written, it simply has not survived to our time. The VOC shipwrights used the overall dimensions from the charters and applied these to known proportional rules that were taught through a master-apprentice relationship and verbally communicated from one generation to the next.

It is important to recognize that in the sixteenth and seventeenth centuries the design methods known to modern naval architecture were not in use.⁹⁵ Dutch shipwrights did not derive the information for curvatures of a ship's hull from two-dimensional plans or lines drawings. Naval architects in England and France were still experimenting with midships molds and end frames to design a vessel's overall shape. These designs were probably applied in the shipyards through the use of molds, gauges, and battens from

which the frame shapes could be easily measured off and transferred to cut timbers in the correct proportions.⁹⁶ Frames were fitted in their respective positions (shortened or angled) through incremental adjustments controlled geometrically or arithmetically.⁹⁷

Obviously, frame-based construction required the development of a specific design method for predetermining the shapes of the frames, which eventually led to more efficient and standardized design methods in England and France in the late seventeenth and eighteenth centuries.⁹⁸ If the shape of a hull were portrayed in a plan, as a mold pattern or a half model, it could more easily be reproduced if a vessel subsequently demonstrated desirable qualities, such as good sailing. Thus, once shipbuilding methods had progressed to the point where curvatures of important timbers, mainly frames, became predetermined and could be taken from plans or models, it became easier to repeat a successful design.⁹⁹ By 1700, the English and French were able to standardize the construction of their ships, replacing the Dutch as the dominant shipbuilders in Europe.¹⁰⁰ Thus, the performance of Dutch ships, in particular men-of-war, compared poorly with that of the English and French.

European shipbuilding manuscripts of the late sixteenth and early seventeenth centuries, such as those written by Matthew Baker, John Wells, and Edmund Bushnell, often discuss hull design based on one or several sectional curves.¹⁰¹ The dimensions of these mold frames were altered fore and aft following specific mathematical proportions for the narrowing (defining breadth) and rising (height above the keel) to delineate a vessel's hull shape. The keel, stem, and sternpost, master frame, and end frames were designed on paper by the application of proportions, using fractions and a pair of compasses to draw sweeping arcs or circles. Arcs and circles played a dominant role in drafting hull shapes in this period.¹⁰² These design methods are similar to the conceptual tradition of fifteenth- and sixteenth-century Italian ship design, although the hull shapes differ (fig. 2-5). English shipbuilding must have been influenced by Venetian or Mediterranean design methods.¹⁰³ It is known that Henry VIII commissioned Italian master shipwrights in the royal yards around 1543, who received one-third more pay than their English colleagues.¹⁰⁴

The earliest northern European manuscript on shipbuilding was written between 1580 and 1630 by Matthew Baker, a shipwright in service of the royal yards in England. Recent studies of Baker's manuscript indicate that he was describing accepted methods rather than new ideas, and the use of midships molds must, therefore, have been introduced before 1580.¹⁰⁵

MASTER FRAMES IN BOTTOM-BASED CONSTRUCTION?

Dutch shipwrights were familiar with the use of midships molds in foreign frame-based ship construction, the use of compasses to draw curves, and application of proportional relations to design mold frames, as is evident in Rembrandt's 1633 painting of VOC shipwright Jan Rijcksen and his wife, Griet Jans (fig. 2-6). In this painting, Rijcksen holds a pair of compasses or dividers in his hand, and on his drafting paper a midships section or master frame, central spine, and transom are depicted (fig. 2-7). This resembles the midships mold design methods of the French and English as discussed by Baker. It is noteworthy to see Rijcksen with a pair of compasses and such a design on paper because he worked in Amsterdam, where bottom-based construction predominated in shipyards at the time Rembrandt made his portrait.

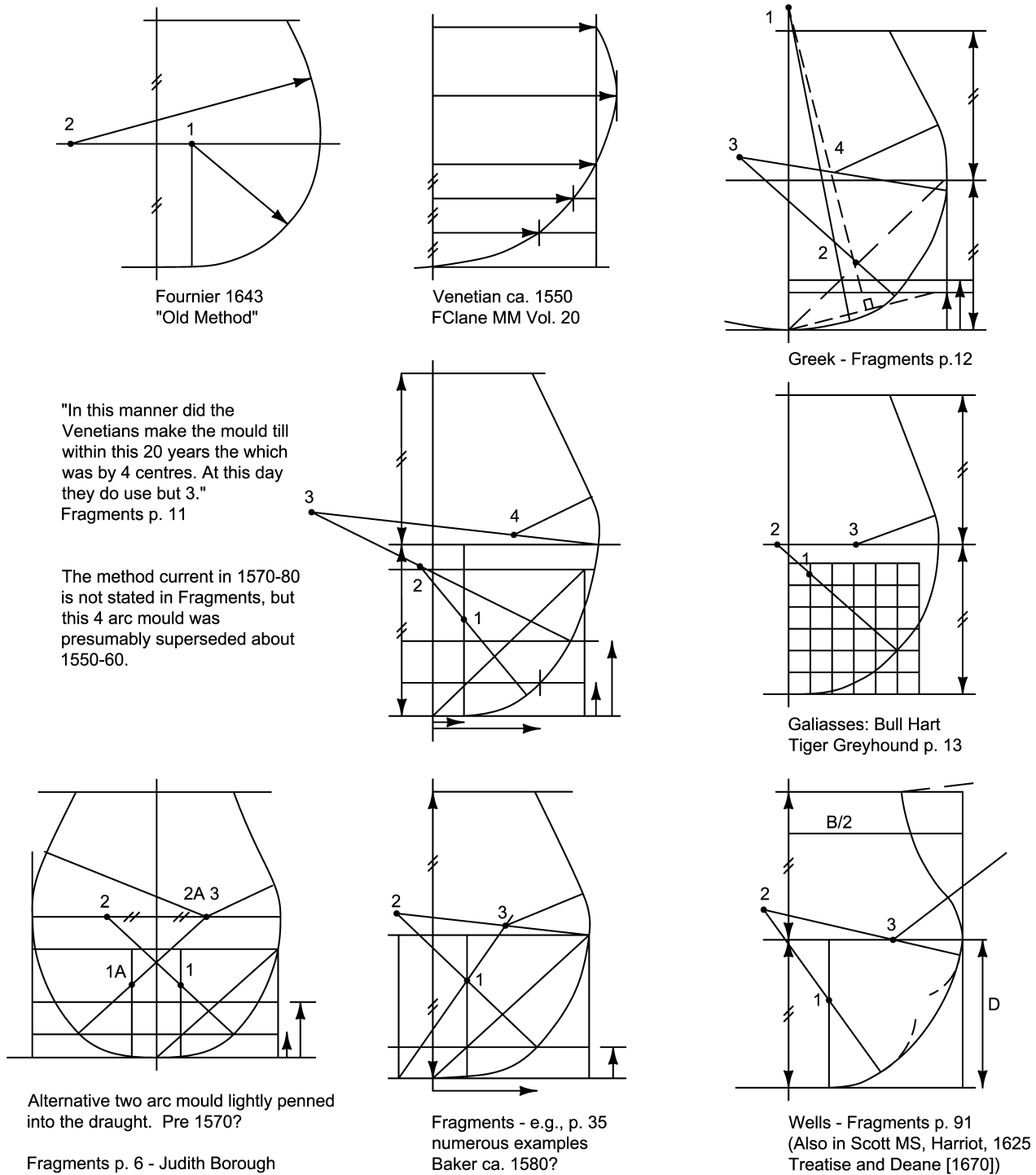


FIGURE 2-5. Selected midships molds. Illustration after Barker, "Fragments of the Pepysian Library," fig. 3.

FIGURE 2-6.
Master shipwright
of the VOC shipyard
in Amsterdam, Jan
Rijcksen, and his wife,
Griet Jans. Painting
by Rembrandt van
Rijn, Queen's Gallery,
Buckingham Palace,
London, 1633 (RCIN
405533). The Royal
Collection © 2008,
Her Majesty Queen
Elizabeth II.

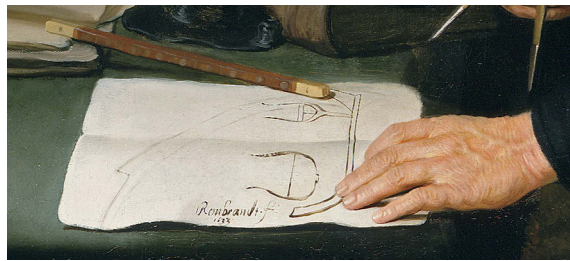


FIGURE 2-7. Detail showing ship's central
spine and master frames. Painting by
Rembrandt van Rijn, Royal Collection, Queen's
Gallery, Buckingham Palace, London, 1633
(RCIN 405533). The Royal Collection © 2008,
Her Majesty Queen Elizabeth II.

Witsen describes the use of a master frame in Dutch bottom-based construction, which was inserted after the assembly of the bottom planking had been completed (fig. 2-8).¹⁰⁶ One floor and two futtocks were installed in the ship's *hals* (neck) at one-third the ship's length from the stem (fig. 2-8c).¹⁰⁷ According to Witsen, only one master floor with a pair of futtocks was placed on the bottom, but there could have been more. The shape of the frame floor was defined by the hull curvature, and that of the first futtocks by the curvature of the bilge. The shipwright did not define this curvature by drawing a mid-ships mold but based it on the shape of the bottom. Witsen does describe how to draw the dimensions of the master frame on paper, but it is not certain whether such drawings were truly used in the shipyard.¹⁰⁸ According to Ab Hoving, the shipwright may have simply used a batten to record the shape of the bottom to define the curve of the master frame in the *hals*.¹⁰⁹

Figure 2-9 illustrates the design of the master frame: horizontal line *a-d* corresponds to the deck level, the curves are drawn from points *e* and *h* with a pair of compasses, *f* and *l* indicate the height of the bottom, *y* is the keel, and *k* denotes the location where the keelson and floors are placed. Witsen explained that to assure the proper curve of the futtocks and the bilge of a model or on paper, a vertical line should be drawn from the

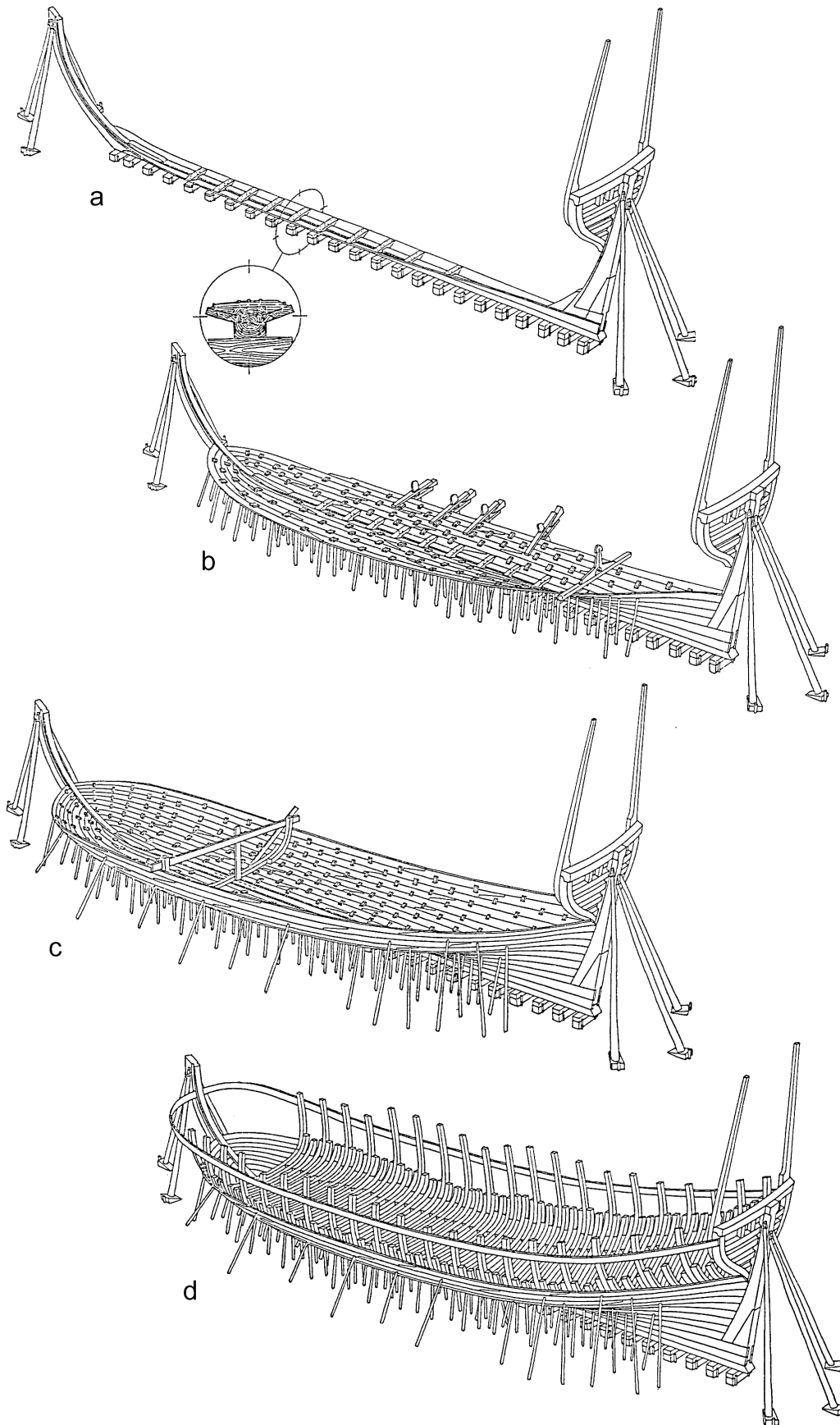


FIGURE 2-8.
Bottom-based
construction method
as described by Witsen.
Illustration by Anton
van de Heuvel.

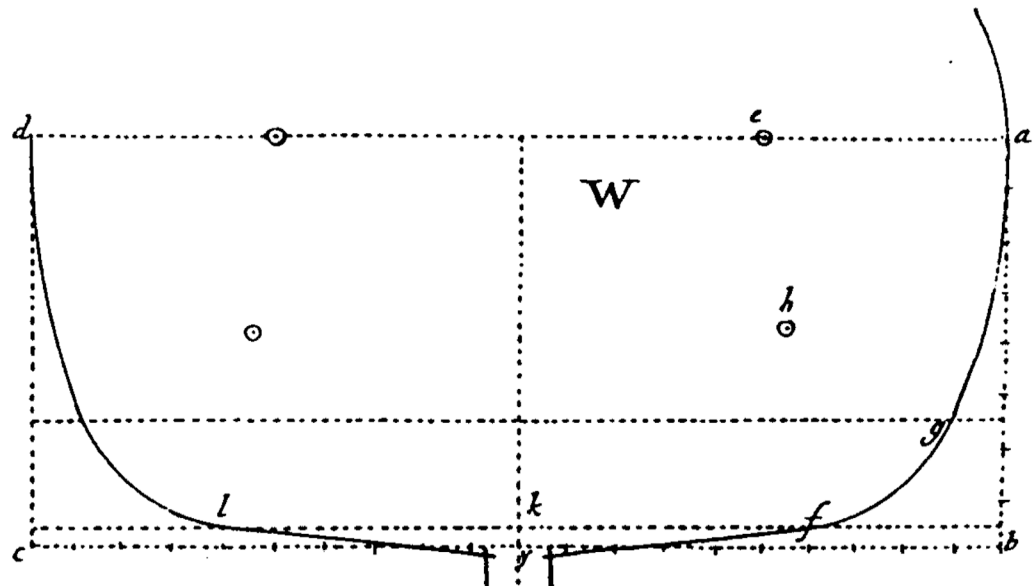


FIGURE 2-9. Midships section as described by Witsen. Illustration from Witsen, *Architectura navalis et reginem nauticum*, numbers LII, W.

center of the deck ($a-d$) through the center of the keel, and the width of the deck should be divided into four equal sections. Unfortunately, the dimensions for Witsen's master frame are not complete. He noted that points f , k , l , and y indicate the rising of the ship's bottom and point f is situated three-fifths of the breadth from the centerline of the keel, but he does not indicate the distance of point f from the lower end of the line it is on. He also mentions that point g is situated approximately two-thirds down from the deck level. The curvature of the first futtock may or may not have been drawn with a pair of compasses from point f to g . Witsen did not specify the radius for the first futtock but indicated that arcs of the same radius were swung from point f and from point g . The curve from f to g was drawn from point h , the intersection of both arcs. Witsen did not discuss the method and radius used to swing the curve between points g and a from point e . In addition, the two arcs were not tangent as is indicated by Witsen's illustration. More interesting is that Witsen's master frame was actually nothing more than a simple section; it indicates the combined curvature of the floor and futtocks as well as the rising of the bottom planking from the keel.¹¹⁰ The latter is different from the curvature of the floors—the garboard strakes were angular and did not sit flush against the floors.

According to Hoving, this so-called master frame demonstrates that Dutch shipbuilders did not use arcs and curvatures in which radii were drawn from specific points by compasses. If they had, Witsen would have provided the dimensions of the radii or the exact point from which the arcs were swept. There was actually no need for the shipwright to apply this design method. Furthermore, Witsen had "borrowed" his so-called Dutch master frame from Georges Fournier's 1646 manuscript *Hydrographie*.¹¹¹ Witsen had access to foreign sources through the Vossius Library in Leiden, where he studied law, and in his own manuscript he discussed shipbuilding methods from foreign manuscripts by Joseph Furttenbach, Bartholomeus Crescentius, Fernando Oliveira, F. Dassié, and Thomas Miller. He also mentions having gathered much information through per-

sonal communication with French and English shipwrights.¹¹² He was a scholar who essentially applied the more scientific methods used in foreign frame-based construction to Dutch bottom-based construction. Witsen's work was not meant for design purposes but as a tool to describe the curve of a vessel's section amidships. Regardless, Dutch scholars such as Witsen and shipwrights like Rijcksen were familiar with foreign shipbuilding techniques employed in England, France, the Iberian Peninsula, and the Mediterranean.

NICOLAES WITSEN'S DESCRIPTION OF BOTTOM-BASED CONSTRUCTION

Nicolaes Witsen is the only seventeenth-century author who discussed the assembly of a ship using a bottom-based construction method. Chapters 8–11 are the most important in Witsen's manuscript for Dutch shipbuilding methods. In these chapters, Witsen described the construction of a *pinas* (warship) 134 Amsterdam ft long (37.94 m), listed its structural timbers (their appearance, function, and measurements), and elaborated step-by-step how to assemble all the timbers in the process of building the ship.¹¹³ Witsen most likely obtained information for these chapters from books and informants—in particular, Amsterdam shipwrights who provided him with details on contemporary Dutch practices.¹¹⁴

According to Witsen, it was not always possible to give conclusive dimensions and proportions of ships because of the numerous pronounced curves and bends in the hull. He points out that two ships, like two humans, never completely resemble each other. His basic approach seemed to be *mutatis mutandis* (change what needs to be changed), which justifies changing whatever the shipwright thought was necessary while building a ship. Witsen adds, however, that devoting more attention to dimensions and proportions yielded a ship with better sailing performance and a more beautiful and elegant appearance. He also specified general distinctions in different types of ships. Warships, for example, were beamier at their tops and centers to withstand attacks and provide better defense, whereas merchantmen were narrower on the top so they required the least amount of crew.¹¹⁵

Witsen does not provide a complete set of dimensions or proportions, but in chapter 11 he does provide a relatively detailed outline of how a large vessel was built in practice (figs. 2-8 and 2-10). The first step was the assembly of the central spine, consisting of the keel, stem, and sternpost. To make the sternpost, for example, the shipwright cut a piece of timber to the desired length, thickness, and width. Then two battens were laid down at a right angle: one extending straight down from the after side of the post's top end (fig. 2-10c, line *a* to *b*) and one horizontal along the sternpost-keel scarf, forming a right angle with the first (line *b* to *f*). After having confirmed with a carpenter's square that the two battens were placed at a right angle, the shipwright marked off points *e* and *f* in case the two battens shifted. The only dimension given in the description of the sternpost is the rake, which was 1 ft per 6 ft of length of the sternpost, equivalent to nine degrees of rake. Witsen did provide proportions for thickness, width, and length of various timbers that made up the stern assembly, since the assembly of parts and their construction sequence were clearly the focus of the discussion. Witsen specifically mentioned that each timber was shaped on the ground, after which it was erected and attached.¹¹⁶

After the keel was laid and the central spine assembled, the garboard strake was inserted. Witsen called the garboard strake the *kielgang* (literally, keelway or keel strake). The garboard strake was not horizontal but angular in order to collect bilge water atop

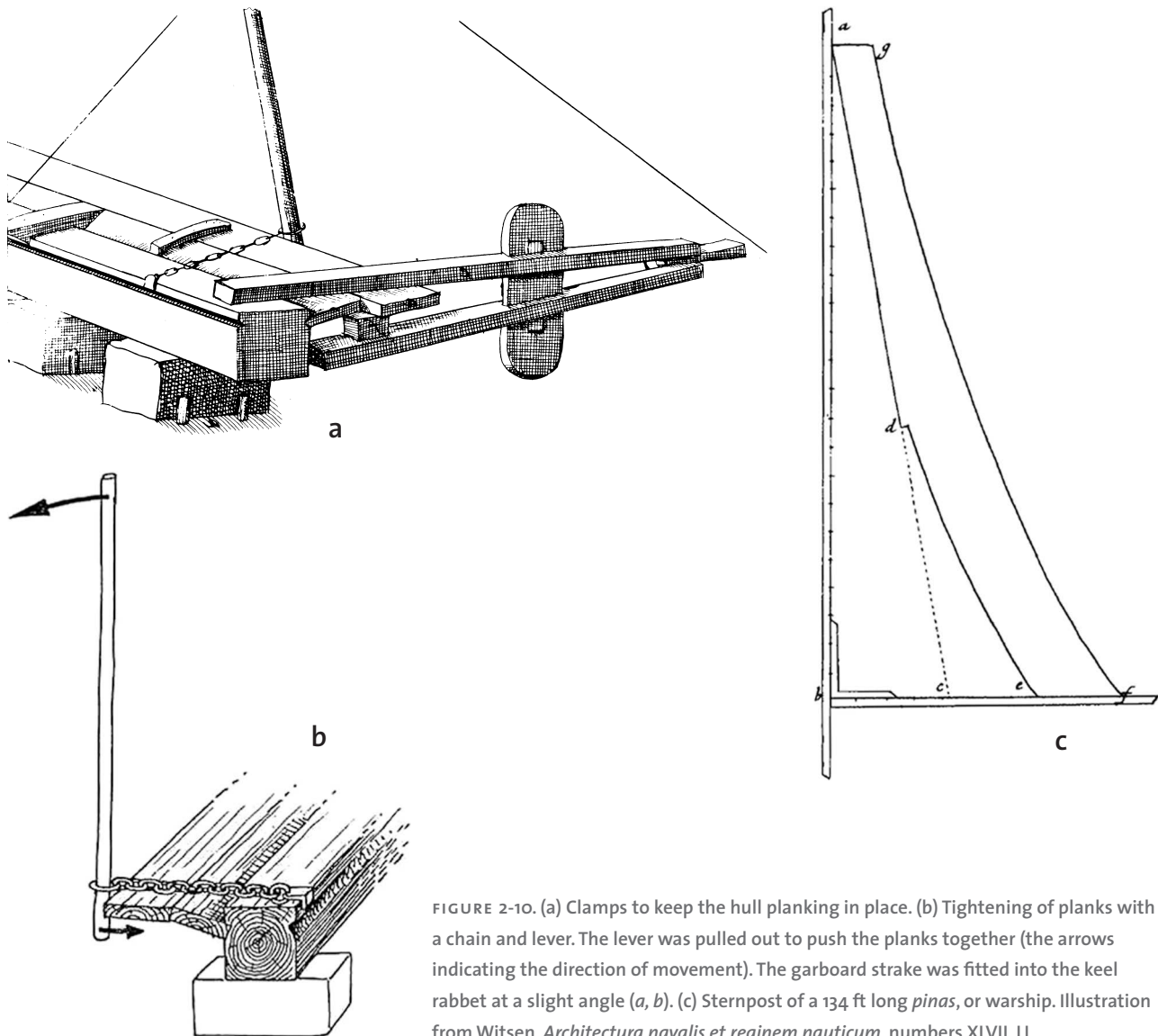


FIGURE 2-10. (a) Clamps to keep the hull planking in place. (b) Tightening of planks with a chain and lever. The lever was pulled out to push the planks together (the arrows indicating the direction of movement). The garboard strake was fitted into the keel rabbet at a slight angle (*a, b*). (c) Sternpost of a 134 ft long *pinas*, or warship. Illustration from Witsen, *Architectura navalis et reginem nauticum*, numbers XLVII, LI.

the keel, which according to Witsen facilitated pumping the water out of the hull (fig. 2-10a, b).¹¹⁷

After garboard strakes were inserted, the bottom was assembled and leveled (see fig. 2-8b). In order to create symmetry on both sides of the keel, a line was strung from stem to sternpost over the centerline of the keel, which was used as a baseline.¹¹⁸ Witsen specifically mentioned that in Amsterdam the bottom planks dictated the shape of the vessel. The bottom planking of the ship comprised approximately two-thirds of the ship's total breadth (see fig. 2-8b).¹¹⁹ Witsen explains that the bottom planking of the hull was tightened or pressed together with a chain and lever (fig. 2-10b) and then temporarily fastened with wooden cleats held in place by iron nails (figs. 2-10 and 2-11). Upon removal of the cleats and nails, the nail holes were plugged with square wooden pegs (*spijkerpen-nen*, or nail plugs). These nail plugs have been found on the archaeological remains of all Dutch-built ships dating to the late sixteenth and seventeenth centuries.¹²⁰ In addition,



FIGURE 2-11. Temporary cleats used in the assembly of the ship's bottom hull planking during the reconstruction of VOC ship *Duifje*. Photograph by Patrick Baker, Western Australian Museum (MA4871-10).



FIGURE 2-12. Wooden shoring poles used on the outside of the ship's hull to support its planking, and temporary cleats used to keep the planking in place during the reconstruction of VOC ship *Duifje*. Photograph by Patrick Baker, Western Australian Museum (MA4868-11).

large wooden clamps were used to keep the hull planks in place and prevent them from bending or slipping downward (see fig. 2-10a). The planks of the vessel were flexed or bent into shape by heating them over fire and then set in place. On the exterior, the bottom planking was supported or propped by wooden shores (fig. 2-12).¹²¹ While cleats, clamps, and shores may have exerted a fair amount of force, they did not provide as solid a foundation for the hull planking as a rigid pre-erected framework did.¹²²

As mentioned earlier, a master frame consisting of one floor and two futtocks was installed in the ship's *hals* at one-third the ship's length. After the remaining floors and first futtocks were installed, the bilges of the ship were planked. The uppermost plank of the bilge planking was placed at one-third the height of the hold.¹²³ Then a transverse beam was laid on the planking edge (fig. 2-13, beam *d*), and the second futtock was fitted on but not attached to the master frame in the ship's neck. A plumb line was dropped from the center of the two futtocks (*c*) over the centerline of the keel (*gb*). From this line, the width between the two second futtocks was measured to ensure symmetry on either side of the keel (the distance from centerline *bg* to the sides *f*). Subsequently, a plumb bob (*h*) was dropped from *f* to check whether the second futtocks flared the same distance out from the bilges.

After these second futtocks were properly installed, additional second futtocks were added to the hull at every fourth frame (see fig. 2-8b). To these futtocks, a *scheerstrook* (sheer strake) was fastened, which served as a master ribband that defined the sheer of the first deck and the vessel. On this ribband, the deck beams and placement of gun ports, masts, and hatches were marked off.¹²⁴ Then deck beams and temporary beams were

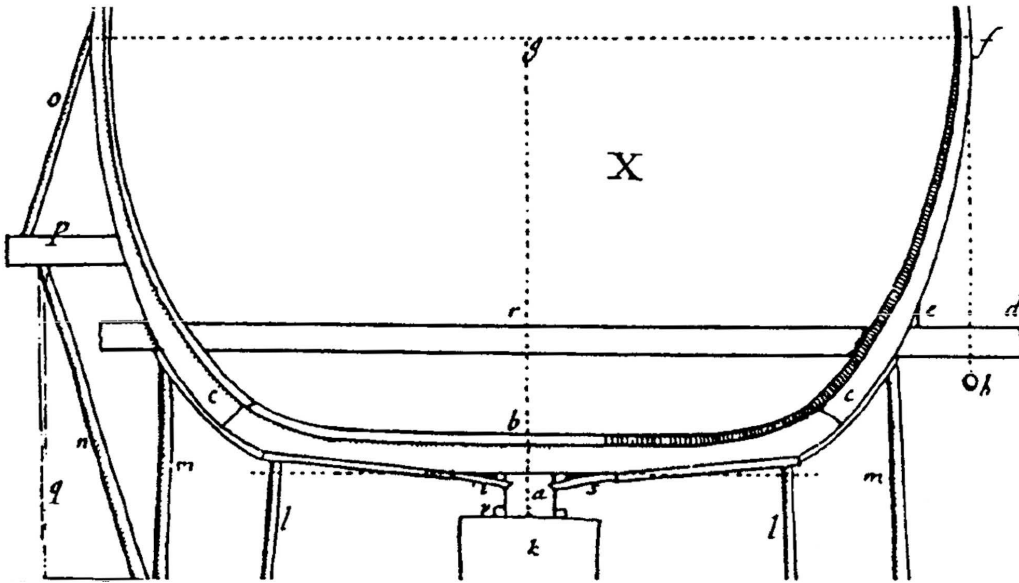


FIGURE 2-13. Master frame after insertion of second futtocks as described by Witsen. Illustration from Witsen, *Architectura navalis et reginem nauticum*, numbers LII, X.

inserted; the latter functioned as a platform for the carpenters while they were working on the upper parts of the ship. The hull planking was added up to the master ribband, the widest part of the hull. The futtocks were not fastened to each other or to the floors but directly to the planking.

When Witsen published his manuscript in 1671, the shipyards of Rotterdam and possibly at other locales in the southern Netherlands had started to build their ships using a frame-based construction method.¹²⁵ This Mediterranean method was to entirely supersede the traditional Dutch method for the construction of warships and large merchantmen by the early eighteenth century.

The coexistence of the two construction methods was first noticed by scholars studying the manuscripts of Witsen and Van IJk, based on a remark by Van IJk that some people in the Noorderkwartier—the region of Holland situated north of the river IJ—were still using bottom-based construction to build ships.¹²⁶ Shipyards in this area, such as at Zaan-dam, Enkhuizen, and Hoorn, continued to use the bottom-based construction sequence as described by Witsen until the late seventeenth century.¹²⁷ A Frenchman named Arnoud, who visited English and Dutch shipyards on an assignment for Admiral Colbert, confirmed that this construction method was still in use in 1670. He stated that the Dutch shipwrights did not insert frames until the first 10 or 12 planks were erected and they adjusted the hull shape by eye as they worked.¹²⁸ In Amsterdam, however, which is outside the Noorderkwartier, experimenting with frame-based construction may have begun as early as the mid-seventeenth century, as suggested by Ludolf Bakhuysen's drawing of the Amsterdam Admiralty shipyard, dated to around 1655–60 (fig. 2-14). It must be noted that even when the bottom-based method was no longer employed for large vessels, it continued to be used in local shipyards for the assembly of inland watercraft or small traditional craft.



FIGURE 2-14. The shipyard of the Amsterdam Admiralty with three warships being constructed using the frame-based method. Ink on painting by Ludolf Bakhuysen, 1655–60, Rijksmuseum Amsterdam (SK-A-1428).

FRAME-BASED CONSTRUCTION IN THE LATE SEVENTEENTH CENTURY

Cornelis van IJk published his book *Nederlandsche scheeps-bouw-konst open gestelt* on shipbuilding and seafaring in 1697. As a shipwright from Delft, Van IJk did not descend from a high social class. He was born and bred in a family of shipwrights and became an apprentice in a shipyard at the age of 12. Van IJk mainly worked on shipyards in the southern Lowlands. He probably decided to write his book after his uncle, who was also a shipwright, left him a thick pile of shipbuilding notes.¹²⁹ Van IJk knew Witsen's work very well, as he praises it in his introduction and cites it quite often. Although Van IJk writes from an experienced point of view as a shipwright, and obviously knows the particulars of his profession very well, Witsen's work is much more detailed.

Van IJk described the design and construction of a complete vessel from step one, as Nicolaes Witsen did, but for a frame-based construction method. Similar to Witsen's construction sequence, the garboard strakes were inserted after the keel was laid and the central spine was assembled (fig. 2-15a). Where Witsen discussed the assembly of the ship's bottom planking, Van IJk continued with the erection of two full main frames consisting of seven timbers each: one floor, two first futtocks, two second futtocks, and two third futtocks (fig. 2-15b). The first pre-assembled main frame was placed at a measured distance from the stem: the sum of half the length of the hull and half the length of the stem. The second one was placed at one-quarter the distance from the first frame to the beginning of the stem. Between these two frames, the shape of the hull did not change. Van IJk did not discuss the design of the two master frames or their dimensions. The curvatures of both frames depended mainly on the beam and depth of the vessel

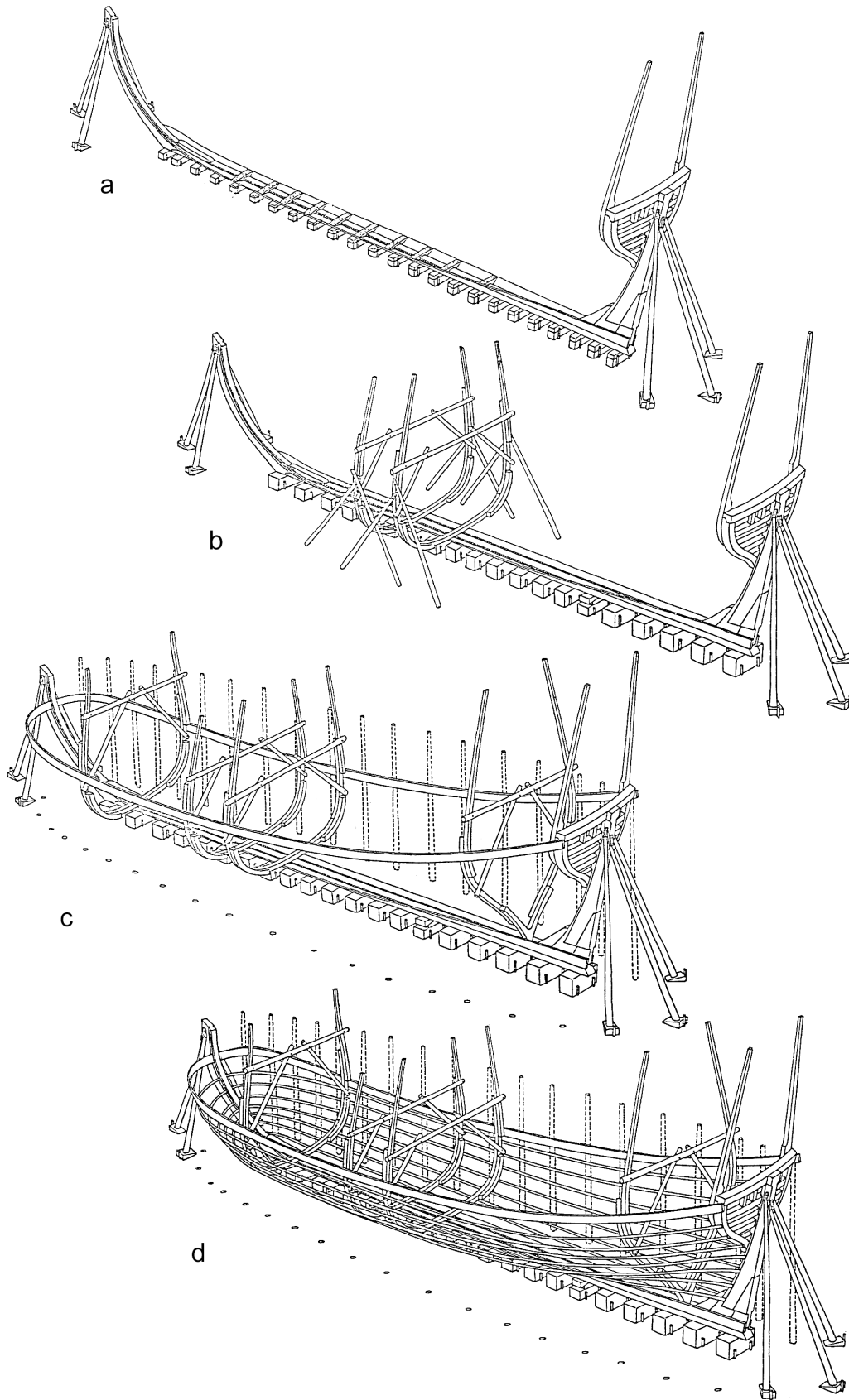


FIGURE 2-15.
Frame-based
construction method
as described by Van IJk.
Illustration by Anton
van de Heuvel.

and on the eye and judgment of the master builder.¹³⁰ If this applied to frame-based construction in late-seventeenth century Holland, it must have applied as well to the bottom-based construction described by Witsen.

Next, vertical poles were driven into the ground around the ship to define the sheer line or the shape of the hull from a bird's-eye view (fig. 2-15c). In addition, a second row of poles was inserted to allow the construction of scaffolding and create a working platform for the upper parts of the hull. On the interior of the first line of poles, the shipwrights fastened the sheer strake or main ribband. Van IJk specifically mentioned that the main ribband was sometimes used to build several similar vessels, as the deck beams, placement of gun ports, masts, and hatches were marked off on it. After this main ribband was fastened, a third full frame was inserted on the scarf of the keel and the stem. The distance from the stem to this new frame was measured, and an end frame was placed at the same distance from the sternpost. Subsequently, 8 to 10 ribbands, depending on the size of the vessel, were placed on each side of the hull between the garboard strakes and main ribband. The ribbands ran the entire length of the hull. They determined the final shape of the hull and indicated the curvature of each hull planking strake. They were also used as a mold for the curvatures of the remaining frames. According to Van IJk, the master shipwright shifted the ribbands up and down along the sides until he was satisfied with their shapes.¹³¹

It is not known exactly when Dutch shipbuilders brought the frame-based construction method, described by Van IJk, into their shipyards, but it must have been some time after 1650 and became established by the early eighteenth century in all major Dutch shipyards. The first body plan of a warship that survived was drawn in 1725: it shows diagonals, as well as a stem and sternpost. This warship, *Twikkelo*, was built by shipwright Paulus van Zwijndregt for the Rotterdam Admiralty (fig. 2-16). It measured 145 ft in length, 41 ft in breadth, and 18 ft in height and carried 56 guns.¹³² By this time, Dutch shipwrights had learned to work with drawings. It had been one century since bottom-based construction had become the foremost method of shipbuilding in the Netherlands. At the time *Batavia* was built in the VOC shipyard of Amsterdam in the late 1620s, frame-based construction was not yet used in that region.

VOC SHIPBUILDING IN THE NETHERLANDS AND THE INDIES

In the first decades after its establishment in 1602, the VOC bought existing vessels and refitted them to build up its fleet. Ideally, the VOC would construct vessels for its service according to its own standards. The company, however, continued to purchase vessels when certain circumstances arose, such as the sudden loss of assets or the need for a quickly outfitted military campaign.¹³³ Purchased ships had to be modified and outfitted for the long journeys to Southeast Asia.¹³⁴

The VOC shipyards could be found in its chamber cities: Amsterdam, Hoorn, Enkhuizen, Rotterdam, Delft, and Middelburg. Unlike the Portuguese, Spanish, and English, the VOC built its large ships at home in the Netherlands. No large Indiamen were built in Asia; this probably allowed the VOC to control the construction costs and the prescribed construction guidelines. The VOC had no facilities and no good resources available in Asia to build such large ships. It had also been problematic to gain access to resources during the VOC's formative years, mainly due to inexperience and hostilities from local people.

Pieter van Dam mentions the anomalous construction of a large Indiaman named

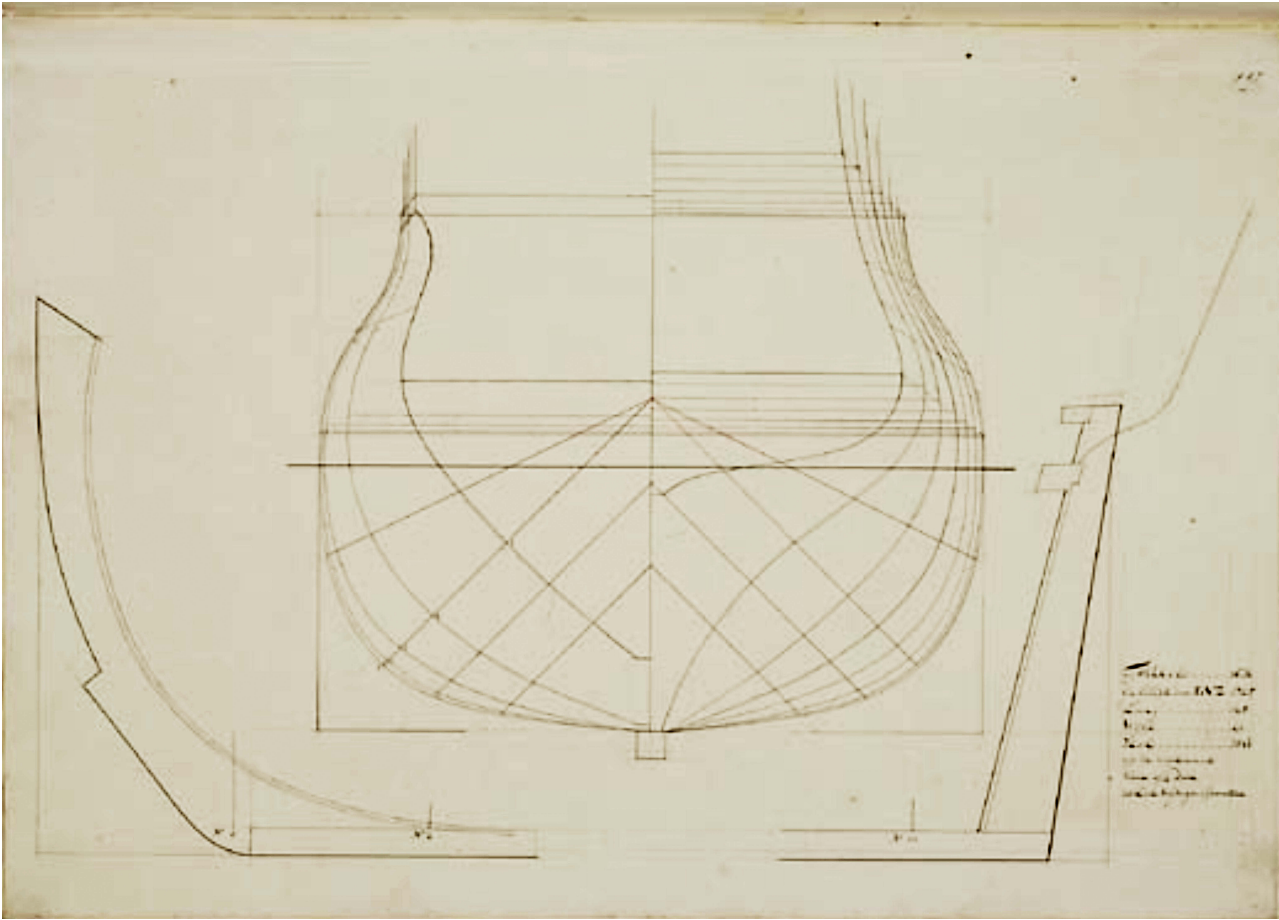


FIGURE 2-16. Body plan of *Twikkelo*, with diagonals, stem, and sternpost, built by Paulus van Zwijndregt in 1725. Illustration by Paulus van Zwijndregt, Maritime Museum Rotterdam (T1126-37).

Standvastigheid in 1690 in the VOC shipyard of Cochin on the southwestern coast of India. The ship was 114 Amsterdam ft (33 m) in length and 27.5 Amsterdam ft (7.80 m) in breadth. According to the records, it cost the VOC factory 34,642 guilders to build such a ship. This amount was roughly one-third what it would have cost to build such a vessel at home; it did not, however, include the wages of the Dutch carpenters who worked on it. The exclusion of the wages was reason enough for the VOC to prohibit the construction of large ships anywhere other than in Holland.¹³⁵ The ostensible reasoning for limiting outside work was the Gentlemen XVII's discomfort with exporting the VOC's shipbuilding knowledge abroad and its desire to avoid higher expenses in Asia. These may simply have been rationalizations to keep profits within the Netherlands.¹³⁶

Jan Pieterzoon Coen, governor-general of the Dutch Indies from 1619 to 1623 and from 1624 to 1629, would have liked to build large ships in Batavia had there not been a deficient number of carpenters, who already had their hands full with the resheathing, replanking, and maintenance of ships.¹³⁷ A chronic lack of ship carpenters and sawyers in VOC shipyards overseas continued throughout the seventeenth century.¹³⁸ The deficiency of craftsmen was evident in all Dutch shipyards in the Indies. The extracts of the daily journal kept in Batavia Castle note that ships were sent elsewhere to be replanked or

resheathed because the VOC shipyards in Jakarta were overstrained and ships had to wait in line for repairs. On 10 June 1626, for example, the ship *Zuid Holland* had just arrived from Holland and was sent to Japan to be renovated and repaired, as its condition was nearly beyond redemption. It is specifically stated that the ship could not be repaired in Jakarta because of a lack of carpenters. Moreover, a large number of ships and yachts in poor condition were already waiting, so it would have been a long time before the vessel could undergo repairs.¹³⁹

The VOC did occasionally try to accommodate the constant shortage of ship carpenters in the Indies. The 12 ships that set sail to the Indies in 1612 under command of Adriaen Martenszoon Block were manned by double the usual number of ship carpenters.¹⁴⁰ Each ship of the 1612 fleet had one master carpenter, assisted by four competent carpenters, who were to stay in the Indies for two or three years.¹⁴¹ In general, each VOC ship set sail from the Netherlands with two carpenters as, for example, the 11 ships of the Nassau Fleet in 1623.¹⁴² Another complicating factor was the large percentage of carpenters who died during the lengthy voyages.

The construction of large ships in Asia was proposed throughout the VOC's existence. In 1651, VOC officials in Batavia suggested the construction of 120- to 200-ton ships at its shipyards in Japara and Siam. These ships were to be used only within the intra-Asiatic network, thereby saving the VOC from sending such vessels from the Netherlands.¹⁴³ The answer to this proposal from the VOC directors in the Netherlands was that the costs would, in fact, be much higher due to the expenses of transporting shipbuilding resources to Asia and the wages of the Dutch shipbuilders sent to Asia. In the late seventeenth century, VOC officials mentioned that it was better to construct ships in the Netherlands, as it provided work and kept the wages and profits within the country, which was preferable to sending money for shipbuilding to the Indies.¹⁴⁴

The VOC did build smaller and lighter craft in the shipyards in the Indies, with a maximum length of 60 Amsterdam ft (17 m).¹⁴⁵ On the island of Onrust, for example, small vessels such as ship's boats, chaloupes, and local watercraft such as *pantchialing* were built (fig. 2-17), and these boats were also maintained there.¹⁴⁶

Special expeditions were organized to construct small vessels on Mauritius or other stations in Asia. In September 1604, the VOC decided to send men with its ship *Eendracht* to Mauritius and Monomotapa (modern-day South Africa) to build two sloops. The crew was instructed to build one sloop of 54 ft (15.3 m) in length, 13 ft (3.7 m) in breadth, and 6 ft (1.7 m) in height amidships.¹⁴⁷ It was to be assembled with oak planks and sheathed with pine boards, animal hair, and filling nails. The second sloop was to be 36 or 38 ft (10.2 m or 10.8 m) in length, 9 ft (2.6 m) in breadth, and 4.5 ft (1.3 m) in height.¹⁴⁸

At sea, Dutch seamen kept an eye out for good anchorages, wood-providing forests with suitable timber, and potential locations for shipyards. The availability, height, and quality of trees for masts and planks were, for example, closely observed during the journey with the yachts *Vos* and *Kraan* under the command of Jan Corneliszoon May to the Arctic Ocean and North America in 1611 and 1612.¹⁴⁹ In the Indies, Pieter van den Broecke noted in 1615: "This island [Ternate] is, to my mind, a very appropriate and well-situated location for our nation, as an abundance of resources are available here, specifically good wood to build light watercraft, such as galleys and frigates, and replank/resheathe ships."¹⁵⁰ These personal opinions about the availability of trees did not necessarily result in actual quality timber for shipbuilding. The Dutch experiences with tropical wood were still in



FIGURE 2-17. View of the island of Onrust, near the town of Batavia. Painting by Johannes Vingboons and/or his staff, 1665–68, Österreichische Nationalbibliothek (E30292C).

their infancy. A galley was, for example, built in Kambello (Ceram, Moluccas) with local timber from so-called *Coninxberger* trees. This was probably a softwood resembling pine that was imported into the Lowlands from Kaliningrad, located between Lithuania and Poland. According to Witsen, the best pine and oak available on the market came from here.¹⁵¹ What the Dutch refer to as *Coninxberger* wood in the Moluccas for the construction of the galley turned out to be local lumber of a slightly different quality. Although the galley proved to be an admirable rowing vessel, it almost literally fell apart due to worm damage within three months after it was built. The wood was apparently not worm resistant, but, to the contrary, was worm attracting.¹⁵²

VOC shipyards in Asia were mainly focused on keeping the fleet and return-voyage ships afloat and shipshape. The company simply had no interest in commencing a colonial shipbuilding program like that of its European counterparts.

CONSTRUCTION COSTS OF INDIAMEN

According to Witsen, it was not realistic to try to calculate the total construction costs of a ship because the cost was different for each ship depending on availability of workers or craftsmen, wood prices, prices of other resources such as iron and copper, and incidental expenses during construction. He does list a cost of 93,685 guilders for a ship of 165 Amsterdam ft (47 m). Making his calculation, he included wood for the hull and masts, nails, tar, wadding, rope, rigging, iron, waterproofing, labor, anchors, and outfitting—everything except the armament.¹⁵³

Van IJk elaborated on Witsen's calculations. He insisted that labor costs were higher because of the number of decks. He calculated an increased weight for the anchors, pointed out an error in Witsen's calculations for the rope work, and specified that Witsen missed an entry for the rigging blocks. Van IJk rectified the amount for building this ship to an estimate of 113,000 guilders. He agreed with Witsen that many factors affected cost

estimates, as many conditions influenced the actual building costs. Last, he added that trying to come up with an estimate would always result in a much cheaper or much more expensive ship.¹⁵⁴ Nevertheless, the construction of large 1,200-ton Indiamen cost roughly 100,000 guilders in the second half of the seventeenth century. Timber and wages for the construction of the hull and masts made up 70% of the total costs.¹⁵⁵ The remaining 30% was allocated to the sails, rigging, anchors, and armament.

The previously mentioned Indiaman *Standvastigheid* was probably the only large VOC ship built by the Dutch in Asia up to 1690. Its construction cost of 34,642 guilders was one-third that of a similar ship in the Netherlands. It may have been cheaper to build ships in the Indies, but it is difficult to compare this amount to estimates provided by Witsen and Van IJk, since it did not include the wages of the Dutch workmen.¹⁵⁶ The costs of construction increased exponentially in the eighteenth century. Ships built according to the shipbuilding charter for the largest VOC ships cost roughly 135,000 to 140,000 guilders in 1735, whereas they cost approximately 184,000 guilders in 1790.¹⁵⁷

All the costs just listed derive from the late seventeenth century. Unfortunately, the total costs for the construction of similar VOC ships in the Netherlands were not written down in the early seventeenth century, but the monetary values of ships were listed when the VOC bought them or if they were appraised during annual inspections. In the fall of 1604, for example, the VOC bought three large ships from private long-distance trading companies: *Amsterdam* (700 tons) at a cost of 21,000 guilders; *Mauritius* (700 tons), 23,500 guilders; and *Witte Leeuw* (540 tons), 55,000 guilders.¹⁵⁸ The last ship was twice as expensive although it was much smaller than the other two. *Witte Leeuw* had just returned from the Indies and had made such a journey only once. In order to prepare these purchased ships for their journey to the Indies, they were refitted in the VOC shipyards, which undoubtedly added a substantial sum to the investment.¹⁵⁹ The amount spent to refit these ships to make them suitable for their intended purpose is not known.

From ships' appraisals in general, it is known that VOC ships were categorized as new, half-worn, or old. These appraisals were part of annual inspections introduced by the VOC directors in Batavia in order to use ships as efficiently as possible. New ships were those considered to be in good condition for the trip to Europe; half-worn ships or ships in moderate condition were used for the intra-Asiatic trade on the China-Japan and India-Arabia routes. Old ships were those considered to be in poor condition. Even if ships were considered old, their careers were not over and they were deployed on short trips, mainly from Batavia to the Spice Islands.¹⁶⁰ Large 800-ton ships that were considered new (a few years old) were generally valued at 80,000 guilders in the 1620s. This amount does not include their armament, which easily added an extra 15,000 guilders.¹⁶¹

CONCLUSION

The invention of the sawmill in 1594 by Cornelis Corneliszoon played a significant role during the sixteenth and seventeenth centuries in advancing the Dutch to the forefront of rapid production of ships. The economizing of labor and material gained by combining carvel planking with the Dutch bottom-based tradition and the efficiency of the Dutch timber trade were contributing factors to the edge afforded to Dutch shipbuilding during this period. While the Dutch adopted carvel building practices from the Mediterranean during this period, they did not further attempt to experiment with the Mediterranean design concept employing frame-based methods.

The manuscripts of Witsen and Van IJk, dating to the late seventeenth century, demonstrate the mnemonic and practical character of Dutch shipbuilding. Witsen appears to describe the design of a midships mold on paper in order to define the amidships curve for a bottom-based hull, but based on his explanation of the construction sequence, it is clearly understood that Dutch shipbuilders following a bottom-based design method could do so perfectly well by eye. Witsen used a midships mold to describe the basic curvature of the hull amidships, so he actually referred to a midships section and not a mold for the design of floors and futtocks. The method described by Witsen did not require hull design on paper. At the time Witsen was writing his manuscripts, the “newer” Mediterranean frame-based method started to take over the “old-fashioned” Dutch bottom-based method. The frame-based method was first introduced to the southern part of the Netherlands and by the beginning of the eighteenth century had made its way up north. By this time the method described by Van IJk was part of the daily routine in the shipyard, but he does not discuss matters of ship design from the naval architects’ point of view. Both Witsen and Van IJk give a thorough explanation of practical matters of shipbuilding, and they are both extremely useful sources on Dutch shipbuilding practices in the seventeenth century. Although more theoretical manuscripts on naval architecture do not exist in the seventeenth century, the Witsen and Van IJk manuscripts are the most comprehensive in Europe to describe the intricacies of shipyard procedures.

The late sixteenth century saw dynamic developments in the Dutch shipbuilding industry as a result of the country’s socioeconomic, technological, and political climates. Two major developments were the lengthening of existing vessels and the introduction of new ship types such as the flute. Also, construction features such as the flat transom were introduced and quickly became widespread for yachts and large ships. From 1595, when the Dutch started sailing to Asia themselves, new ships had to be designed and constructed for the long-distance trading voyages to Asia and back. Not much is known of these ships from historical sources in the late sixteenth and early seventeenth centuries. With the founding of the VOC in 1602, specific guidelines for its shipwrights were written down in so-called construction charters, which are important documents for the study of the Dutch East India yachts and ships and demonstrate that the vessels were sturdily constructed and, in the early seventeenth century, had two decks.

It is not specifically known what made these fully rigged ships so different from other mercantile ships, other than their obvious physical features such as a flat transom, pine sheathing, and deck arrangement, and what specific customized features were considered important for their long voyage to Asia. In the following chapters, the archaeological remains of *Batavia* and other Dutch-built long-distance trading vessels are assessed to explain more about how these ships were constructed. The archaeological evidence is then compared to what is known about VOC shipbuilding from its charters and the manuscripts of Witsen and Van IJk.

3

SITE FORMATION, EXCAVATION, AND RECONSTRUCTION

This chapter evaluates the excavation and recording methods pertaining to *Batavia*'s hull and their influence on this study: the archaeological circumstances in which *Batavia*'s wreck was found, starting with the site's location, the wrecking event, and the site's formation; the excavation methodology when directly related to the hull study; and the methodology used to record and draw *Batavia*'s hull timbers. Then the reassembly of the ship's hull for museum display and the methods used to determine *Batavia*'s lines from the reassembled structure are discussed.

THE FORMATION OF THE SHIPWRECK SITE

The Houtman Abrolhos is an archipelago of islands and reefs situated about 60 km off the Western Australian coast. It includes one distinct island and three main island groups: North Island, the Pelsaert Group, also known as the Southern Group, the Easter Group, and the Wallabi Group (fig. 3-1). The remains of the *Batavia* lie at a depth of 3 to 7 m at the southwestern end of Morning Reef in the Wallabi Group. The wreck site covers an area of about 50 m in length and 15 m in width and is oriented in a north-south direction, with the ship's bow at the northern end on top of the reef edge in the shallower part of the site (figs. 3-2 and 3-3).

Over time, portions of *Batavia*'s hull structure were buried beneath a layer of concretion, sand, and coral lumps. They were pressed into the reef by the heavy weight of the ship's cargo, equipment, and the belongings of the people onboard. The cavity left behind after the wreck's excavation and the removal of the ship's timbers is still visible today when seas are calm. From a bird's-eye view, it serves as a visual memorial of *Batavia*'s shipwrecking event. In addition to the imprint created by *Batavia*'s hull timbers, 12 iron cannon and at least 8 anchors—7 on the shipwreck site and 1 on the reef—were purposely left in situ to maintain the integrity of the shipwreck site for its visitors.¹

The hull timbers of *Batavia*'s port-side stern at the southern end of the wreck site were first observed during the 1972–73 excavation season. The archaeologists were surprised to find such a substantial portion of the ship's hull structure because of the conditions at the site, which included strong water movement due to the swell and the shallow, exposed sea bottom on which the wreck was situated.²

According to Pelsaert's declaration to the Council of Justice in July 1629, *Batavia* lost its rudder when it struck the reef for the first time in the early-morning hours of 4 June 1629. After the ship's second collision with the reef, it was stuck in 12 ft (3.4 m) of water at its bow and 18 ft (5.1 m) aft at the transom.³ These depths are consistent with the conditions in which the shipwreck was found more than 300 years later. Unfortunately, the ship did not last very long in this exposed situation. During his interrogation of the mutiny suspects, Pelsaert inquired:

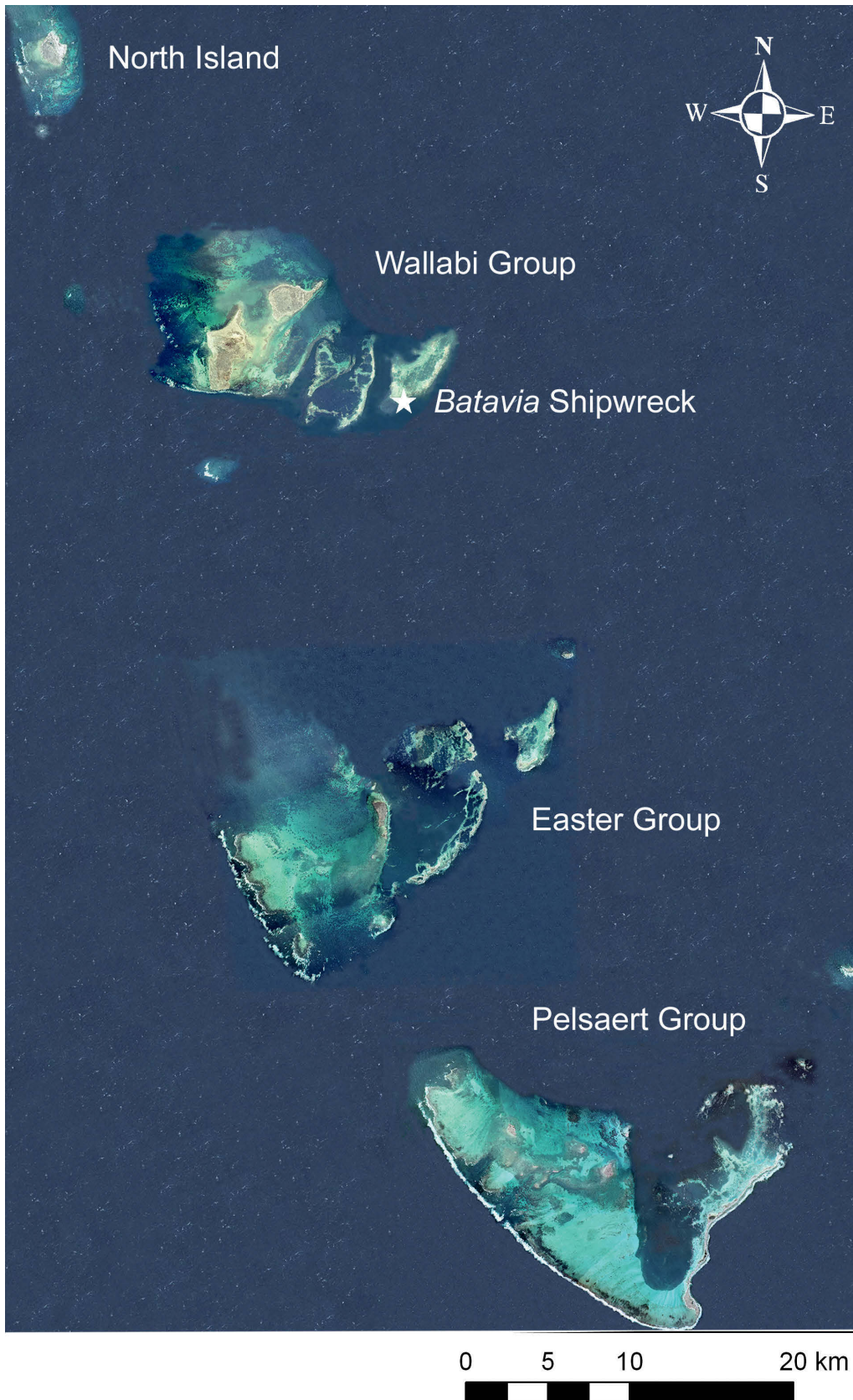


FIGURE 3-1.
Location of the *Batavia*
shipwreck in the
Houtman Abrolhos
islands. GIS by author.

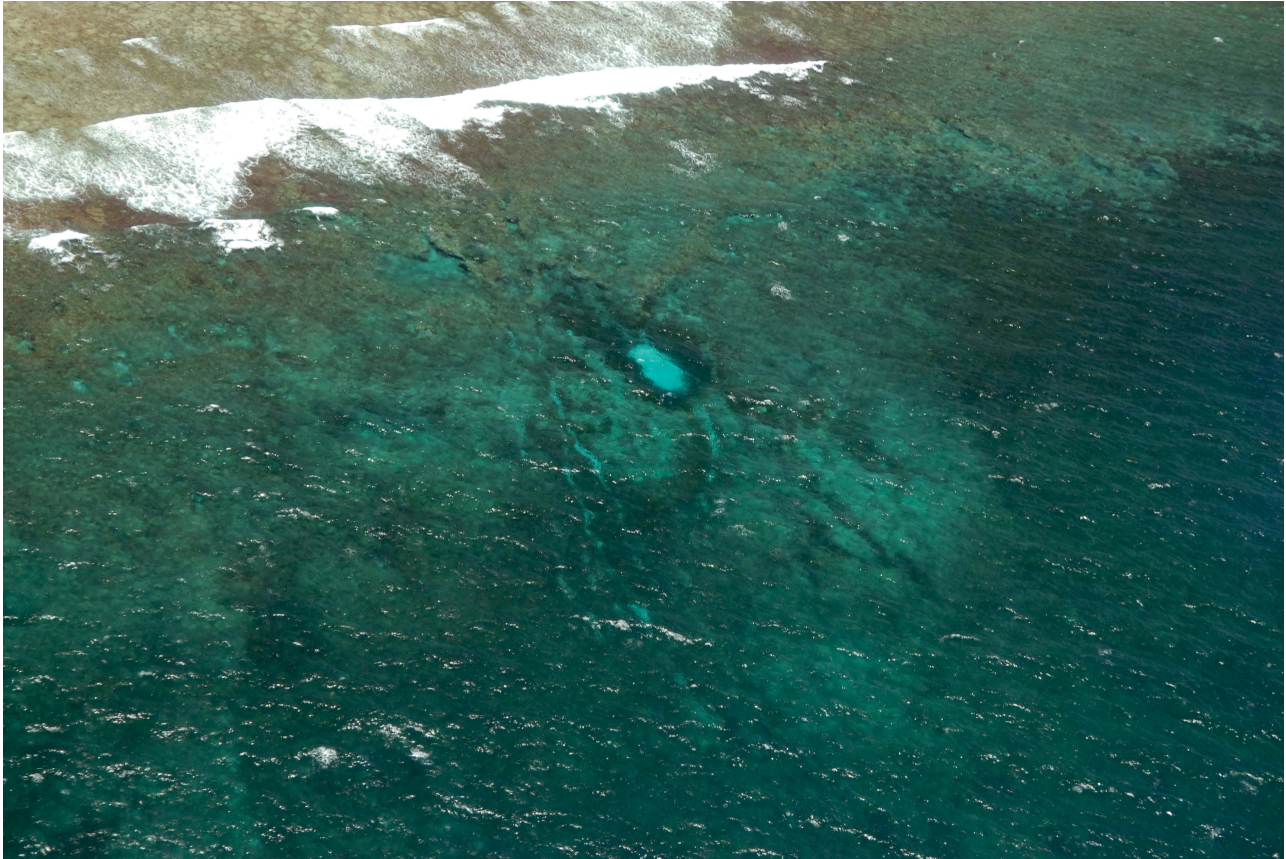


FIGURE 3-2.
Morning Reef and the
Batavia shipwreck
site. Photograph by
Patrick Baker, Western
Australian Museum.

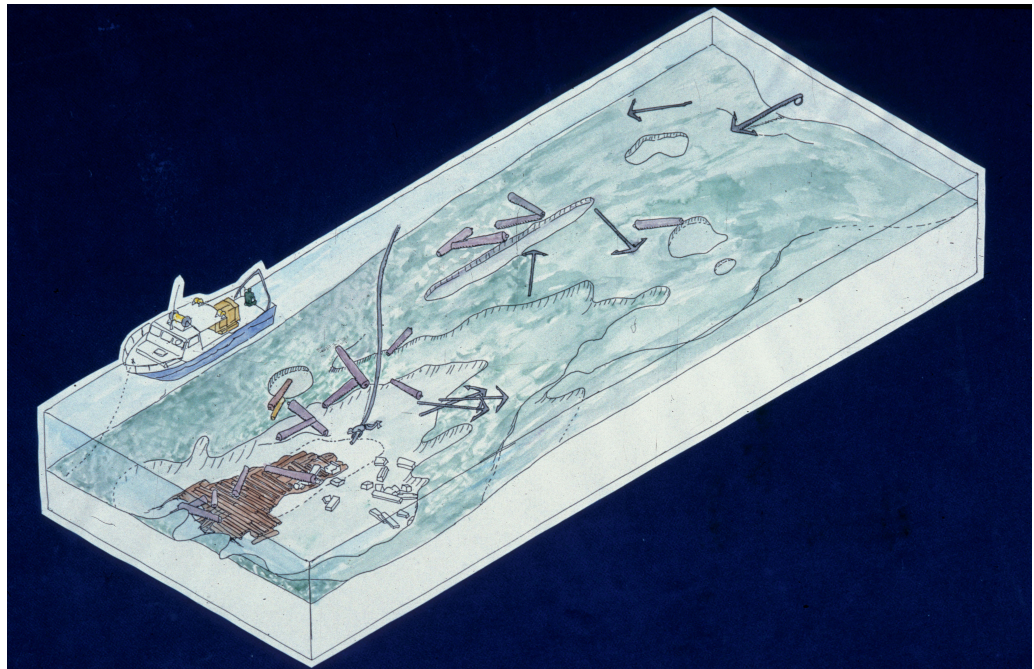


FIGURE 3-3. Isometric view of the *Batavia* shipwreck excavation site. Illustration by Patrick Baker, Western Australian Museum (BT-D-0033).

How matters had fared regarding the ship or wreck, and how long it had remained whole after having been wrecked, they said that for eight days it had mostly held together, but the transom and other upper works had been washed away first of all, during which time it had mostly blown very hard and there was an enormous surf, and at last the starboard side had been thrown out.⁴

Pelsaert states in his journal that upon his return to the Houtman Abrolhos on 16 September, sections of *Batavia*'s bow and stern were still visible above the water's surface. At his departure from the islands on 15 November, those sections had all washed away as a result of the strong currents and the fierce surf dashing against the timbers. He observed that only the keel and the few remains of the ship's hold were kept in place below the weight of ordnance, anchors, rope work, and other heavy items:⁵

Toward evening [18 September], [we] sailed to the wreck [and] found that the ship was lying in several pieces, namely, a section of the keel, with the adjacent bottom of the hold, all above water had been washed away, all except for a small part of the upper fashion piece protruding above the water surface at the stern; it was almost exactly in the same place where the ship had first struck. Part of the bow, broken off at the rider bitts was thrown wholly on the shallow; therein were lying two pieces of ordnance, one of metal [bronze], with one of iron, fallen from the gun carriages without anything more. Near the bow of the ship was lying also one part of its side stern broken off at the starboard mizzen gun port. Then there were several smaller pieces that had drifted apart to various places, so that there did not look to be much hope of salvaging much of the money or other goods.⁶

Pelsaert went on to mention that he sailed to some of the neighboring islands and reefs on 25 October to check whether goods and valuables had washed ashore but found only ship timbers that littered the islands.⁷

It is, therefore, remarkable that such a substantial section of *Batavia*'s stern has survived, as Pelsaert's journal suggests differently. In addition, the site's conditions are not favorable for the preservation of ship's timbers amid fierce breakers dashing against the reef during southwesterly winds. The hull structure that survived three centuries of immersion was initially well protected from the elements, pressed into the reef and sealed off by the ship's stone ballast, cannon, and cannon balls. These materials created a protective seal of artifacts, iron concretion, and sand to encapsulate the timbers. Without this protection more of *Batavia*'s timbers would surely have been destroyed by excessive water movement and biological degradation.

Interestingly, however, the site's formation has caused postconservation problems associated with the acid deterioration of the wood matrix. The iron artifacts, such as the cannon, cannon balls, and fittings, corroded, and their corrosion products leached into the wood cells of *Batavia*'s timbers. This iron corrosion caused the formation of a dense, encapsulating concretion over parts of the timber remains. Under the layers of deposited sand and concretion, an anaerobic environment developed, where sulfate-reducing bacteria were active, producing high concentrations of sulfide ions. The reaction between the soluble iron chloride corrosion products and the sulfide ions caused the precipitation of iron sulfides, mainly pyrite (FeS_2) and pyrrhotite (FeS), within the wood structure in

situ. The conservation treatment did not extract these insoluble corrosion products, and the complex oxidation of these iron sulfides and other sulfide-containing compounds has since led to the production of acidic by-products that continue to cause ongoing deterioration of *Batavia*'s timbers.⁸

BATAVIA'S HULL STRUCTURE

The hull structure found by archaeologists comprised the transom and the after port side of the vessel, including part of the sternpost, fashion piece, part of the upper fashion piece, 5 transom beams, part of the wing transom, 5 transom knees, the remains of 21 hull planking strakes—including 3 wales—12 strakes of ceiling planking plus a shelf clamp, 46 frames, 1 gun port lid, 2 deck beams, 2 hanging knees, and 1 lodging deck knee. Neither the keel nor any timbers from *Batavia*'s starboard side have survived.⁹ The hull structure is preserved up to above the lower deck.

A substantial part of the hull has been reassembled and is displayed in the Western Australian Museum—Shipwreck Galleries in Fremantle (fig. 3-4). The structure on display measures 11 m in length, 6.5 m in height, and 4 m in width. Many other timbers still remain in storage at the museum, however. These timbers are separate because they were poorly preserved, their precise location on the hull was not known at the time of reassembly, or they are detached or fragmented (figs. 3-5 through 3-8). The timbers in

FIGURE 3-4.
Remains of *Batavia* on display in the Western Australian Museum—Shipwreck Galleries, Fremantle. Photograph by author.



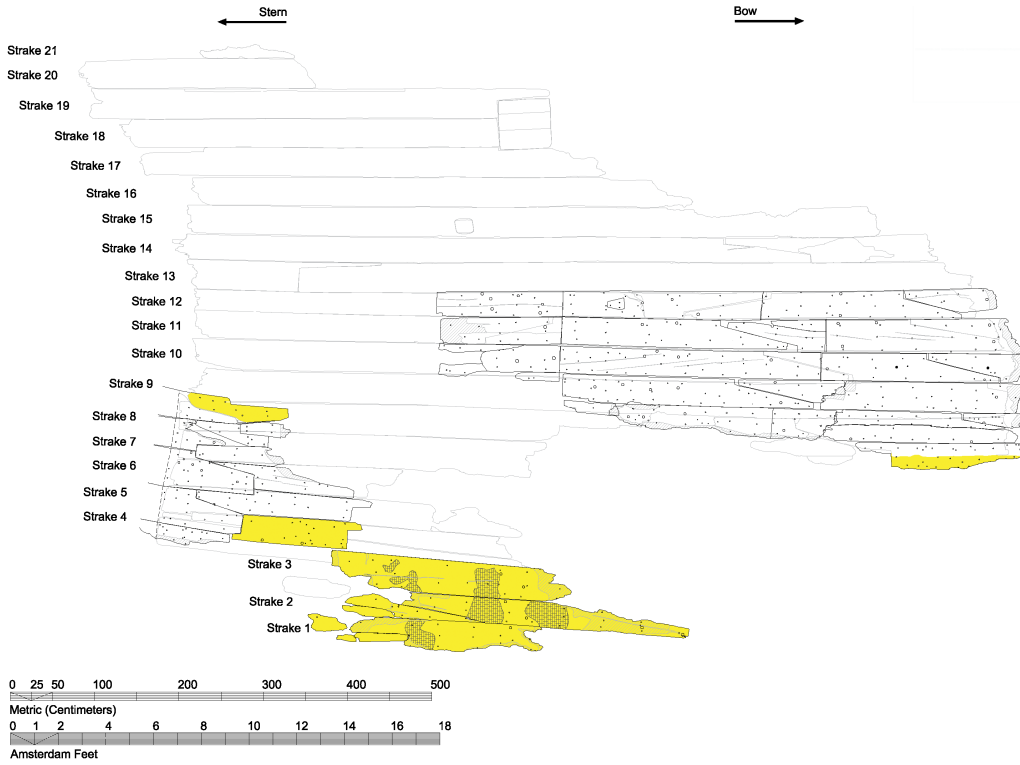


FIGURE 3-5.
Outer layer of *Batavia's* hull planking, port side, interior face. All timbers excluded from display indicated in yellow. Inner layer of hull planking is outlined in gray for orientation. Illustration by author.

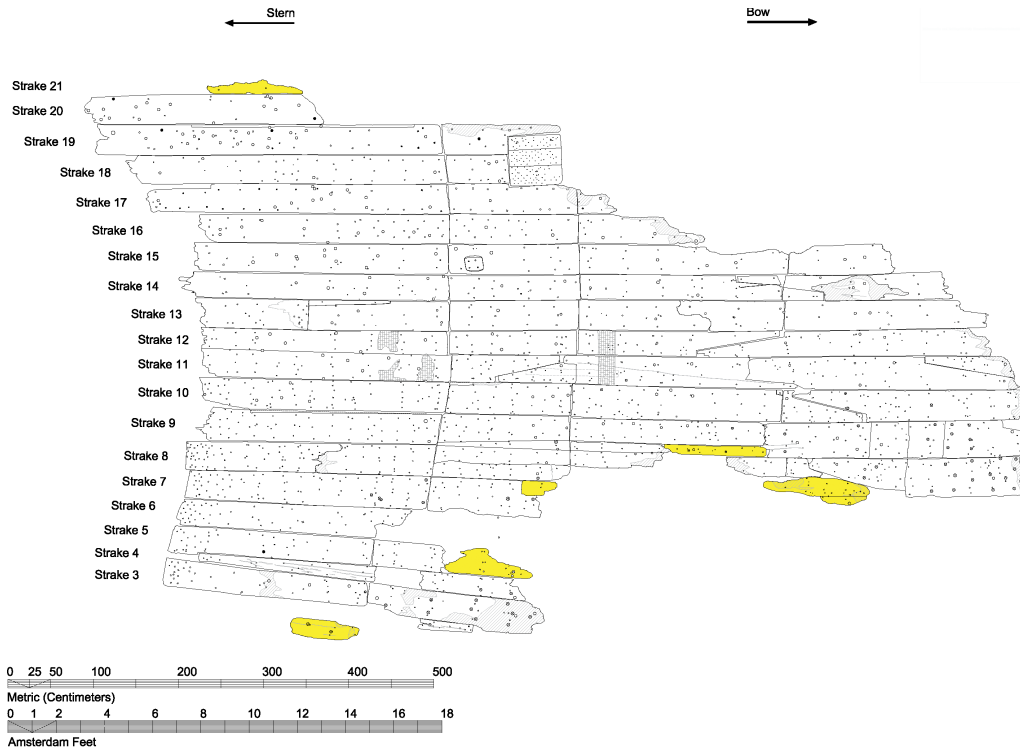
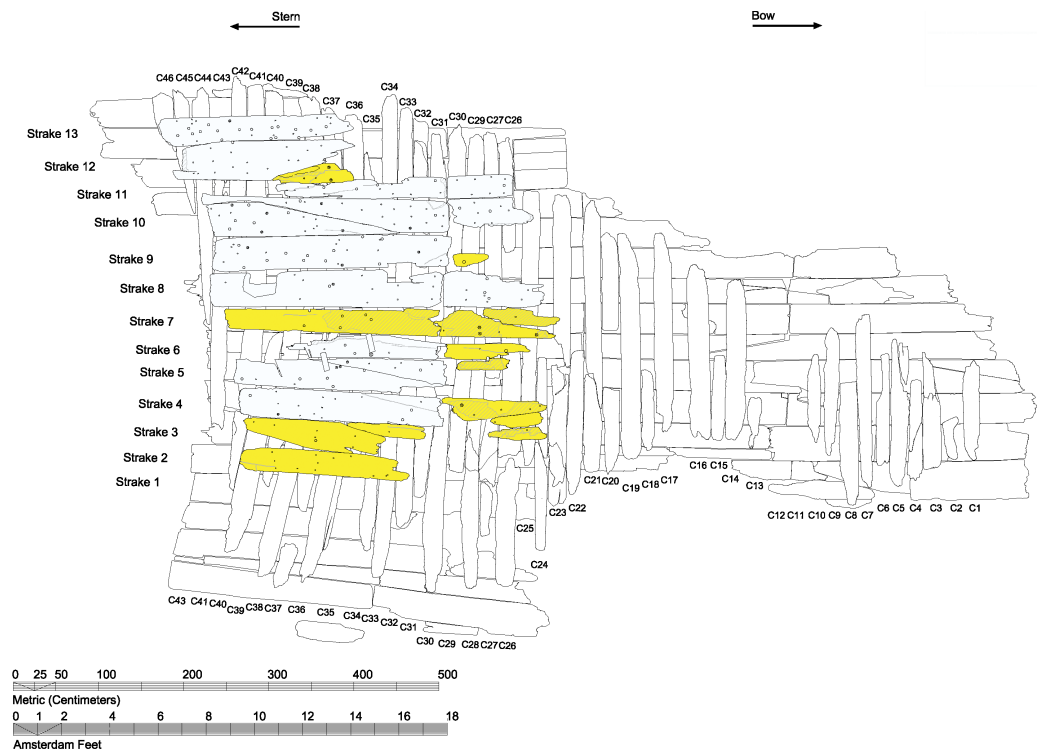


FIGURE 3-6.
Inner layer of *Batavia's* hull planking, port side, interior face. All timbers excluded from display indicated in yellow. Illustration by author.

FIGURE 3-7.
Frame timbers of
Batavia's hull, port side,
interior face. All timbers
excluded from display
indicated in yellow.
Illustration by author.



FIGURE 3-8.
Ceiling planking of
Batavia's hull, port side,
interior face. All timbers
excluded from display
indicated in yellow.
Illustration by author.



storage include all pine sheathing, all frame wedges, fragments of the ceiling planking and its inner floorboards, and several hull planks and frame timbers.

THE EXCAVATION OF BATAVIA'S HULL

The timbers were exposed and raised in sections during the three fieldwork seasons from 17 December 1972 to 8 April 1975.¹⁰ The northernmost section, or forward part of the hull structure, was raised in the first excavation season from 17 December 1972 to 6 May 1973 (figs. 3-9 through 3-11).¹¹ This section is part of the side of the ship's hull and includes remnants of frames, two layers of hull planking, and one or two layers of pine sheathing. During the second season, 1 December 1973 to 4 April 1974, the middle section of hull structure was raised, which included a gun port.¹² No pine sheathing has been preserved from this segment. In the third and last excavation season from 21 December 1974 to 8 April 1975, the aftermost section of the stern was excavated. In addition to another section of the ship's side, the transom timbers and sternpost were raised.¹³ This section also includes the few remains of the lower or main deck of the ship. Pine sheathing was mainly preserved on the transom planking of the ship. The outer layer of hull planking in this section is poorly preserved and probably worn down due to the abrasion of the ship chafing against the seabed before settling firmly into the sediment. This wear and tear of the timbers is most apparent on the exterior corner where the hull planking meets the transom (fig. 3-12).

Between excavation seasons, timbers exposed in the previous season were covered

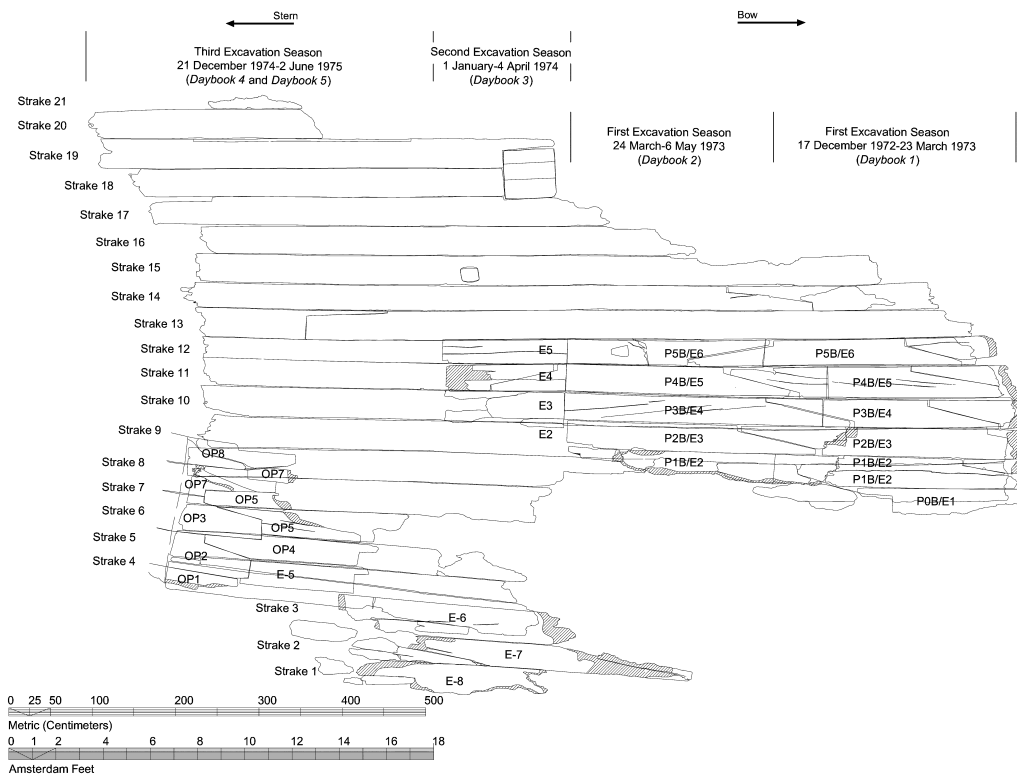


FIGURE 3-9. Field numbers per excavation period for the outer layer of *Batavia*'s hull planking, port side, interior face. Inner layer of hull planking is outlined in gray for orientation. Illustration by author.

FIGURE 3-10.

Field numbers per excavation period for the inner layer of *Batavia*'s hull planking, port side, interior face. Illustration by author.

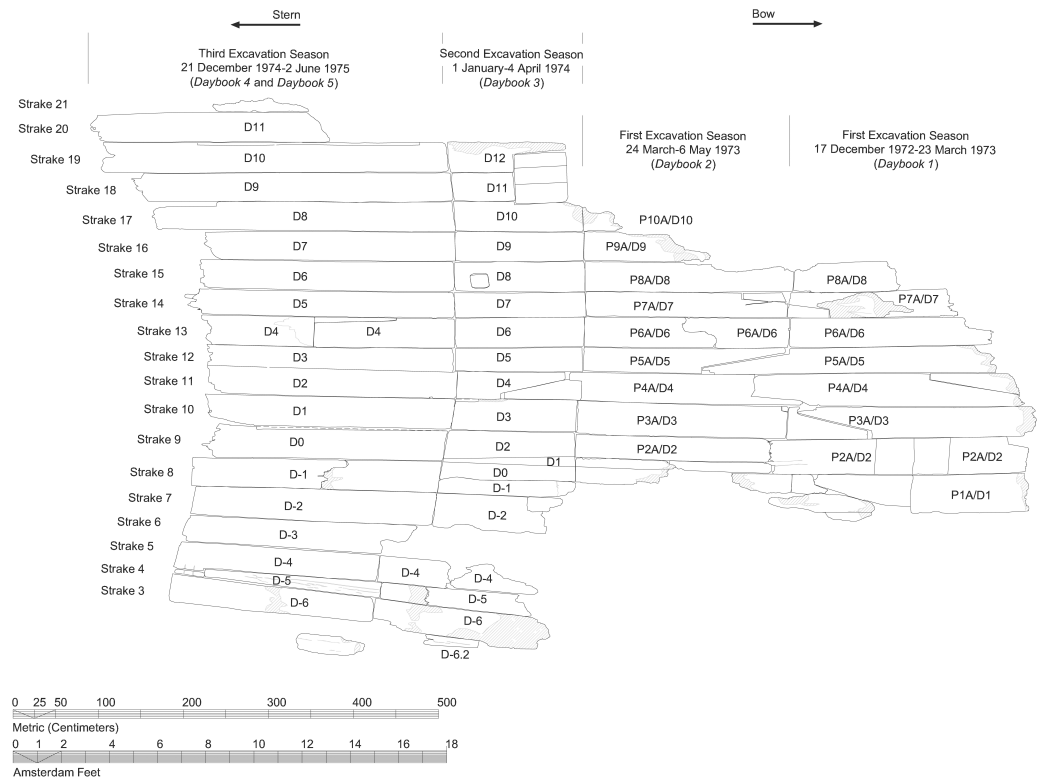


FIGURE 3-11.

Field numbers per excavation period for the ceiling planking and frames of *Batavia*'s hull, port side, interior face. Illustration by author.





FIGURE 3-12.

Corner of *Batavia*'s side and transom showing erosion of the timbers. Photograph by Patrick Baker, Western Australian Museum (BT-T-0455).

with sand and coral bags held down by sections of steel railroad track to protect the timbers until the next excavation season. The last of the *Batavia* timbers were brought to the surface on 8 April 1975. The only wood remaining on the site consisted of isolated fragments and pockets of pine sheathing that have not been raised. The timbers were processed in the excavation camp until 16 April 1975. According to the project log, "A significant event took place at 4:30 p.m. today. The last of the major timbers were processed. Only a few odds and ends remained to be done."¹⁴ The timbers were transported several days later to Fremantle, where they were stored in tanks filled with fresh water for one to two years until conservation treatment commenced.

After *Batavia*'s timbers had been cleaned of coral growth and soaked in deionized water during their last stage of desalination, they were placed in large tanks and saturated with polyethylene glycol (PEG). They were then placed in a dehumidifying chamber where the PEG, as it solidified, gradually replaced the water in the wood cells and the timbers dried slowly over two or three years in a controlled environment. The chamber prevented the timbers from drying too quickly and minimized the risk of their warping

or cracking. In spite of this precaution, many timbers show surface cracking not obvious prior to their conservation treatment.

The conservation treatment of the first batch of timbers was completed in December 1981. Other batches followed suit every six months until all timbers had been conserved. However, the retreatment of timbers has been ongoing since. Information on the transport of the timbers and their conservation method, including their saturation with PEG 1500, has been discussed by various authors involved in the conservation treatment efforts, including Ian MacLeod, James Pang, Ian Godfrey, and Vicki Richards.¹⁵

The methods of recording—in situ and directly after excavation—and excavating the *Batavia* hull structure and timbers have been discussed in detail in an article by Patrick Baker and Jeremy Green, and by Green in the 1989 published excavation report.¹⁶ The methods are briefly discussed here to evaluate their influence on this study of *Batavia*'s hull remains and their reconstruction. The discussion is intended to complement and update any information published elsewhere.

Underwater photography, both standard and stereo, was used to record *Batavia*'s timbers once they had been exposed and to document the individually tagged timbers after excavation in the base camp. Conventional measuring systems were considered too impractical for use in the conditions surrounding the *Batavia* site. The surge made it difficult, but not impossible, to obtain accurate measurements from measuring tapes, bubble tubes, or differential pressure gauges.¹⁷

The three seasons of excavation demonstrated, however, that it was possible to document and raise a large amount of heavy ship timbers despite the presence of strong currents, heavy swells, and rough seas. In the 1970s, the excavation of the intact hull structure from this site was unprecedented for archaeologists working in the Southern Hemisphere. Such excavation has not since occurred on any other shipwreck site in Australasian waters.

After being recorded in situ, the timbers were lifted from, or sawn off, the intact hull structure and raised from the seabed (figs. 3-13 and 3-14). The transom knees and hull and ceiling planking were sawn underwater with a pneumatic chainsaw. The sections, measuring approximately 2.97, 2.41, 1.70, and 3.91 m in width from bow to stern—north to south—were easier to handle in hazardous conditions and presented less of a storage problem at the temporary holding area on Beacon Island (see figs. 3-9 through 3-11). It was the most obvious solution for many logistical problems at the time of excavation. The long planking strakes could not have been recovered in their entirety due to the site's excavation in sections. This excavation method made it unfeasible to raise the 10 m timbers, as they continued underneath the sections that still needed to be exposed. In retrospect, the raising of complete hull timbers may have facilitated a more accurate reconstruction. After the reassembly of the timbers in the Shipwreck Galleries, the saw cuts in the planking strakes remain visible even though they have been concealed as much as possible. The adhesive used to repair broken timbers was 75% (w/v) polyvinylpyrrolidone (PVP) in ethanol, and the filling solution for covering the saw cuts was 90% PEG 3350/10% PVP in ethanol (w/w).¹⁸

In contrast to the planking, *Batavia*'s frame timbers were removed from the structure by gently easing them off the planking by hand or with the help of a crowbar, which was possible because the iron bolts that once held the timbers together had corroded away. The frames, transom beams, fashion piece, and deck timbers were all raised individually

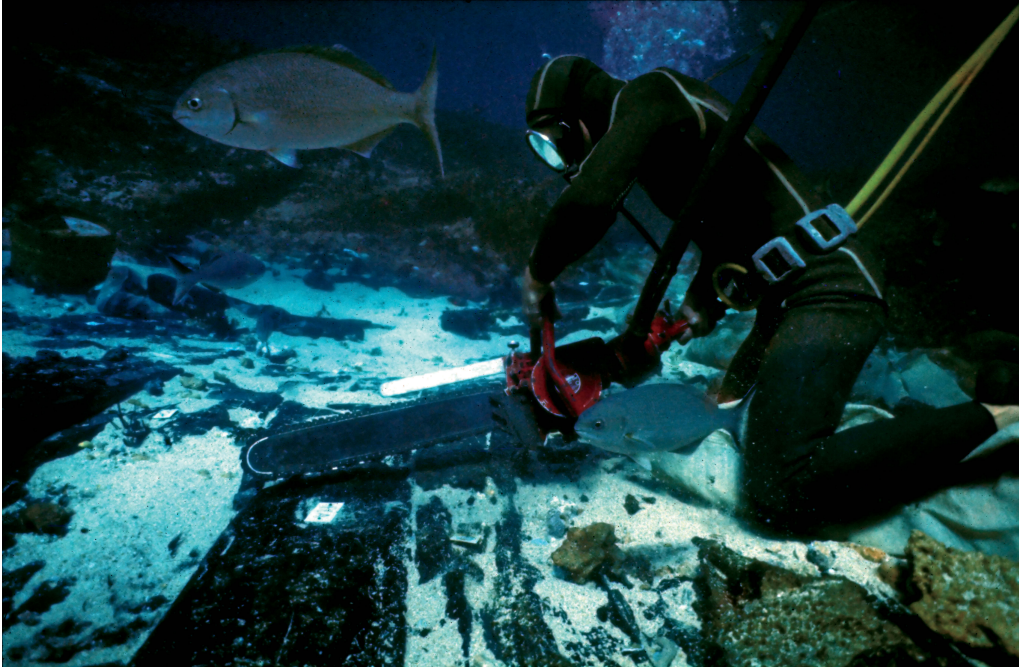


FIGURE 3-13.
Diver sawing *Batavia*'s
hull planking with a
pneumatic chainsaw
during the first
excavation season.
Photograph by Jeremy
Green, Western
Australian Museum
(BT-A-0223).



FIGURE 3-14.
Batavia's fashion
piece being raised
with a winch on
the excavation boat
Henrietta during
the third excavation
season. Photograph by
Patrick Baker, Western
Australian Museum
(BT-A-0840).

and not sawn in easily manageable sections. The fashion piece is the single largest timber raised intact from the seabed, measuring 4.6 m in length, 60 cm in width, and 32 cm in thickness.

After the timbers were loosened from the hull structure, they were placed in a sling of nylon rope encased in canvas. The sling was then attached to a steel cable from the excavation boat's winch, and the timbers were lifted aboard the vessel and brought to the excavation camp on Beacon Island (see fig. 3-14).

TIMBER RECORDING ON THE SEABED

Each individual timber was tagged in situ on the seabed with a PVC label denoting the timber's temporary field number (fig. 3-15). This number was written on the tag with a waterproof permanent marker pen and consisted of an alphabetical prefix followed by a number. The prefix designated the type of timber, such as frame or hull plank, and the number for each timber was consecutive within the types of timber identified on the seabed. The alphabetical prefix related to the basic layers within the ship's hull structure from its interior to its exterior as viewed on the wreck site. The alphabetical prefixes for the timbers' field numbers are listed in table 3-1.

The port side of the ship's hull from its interior to its exterior essentially consists of a pine cargo or inner floor on top of ceiling planking (B-layer), frames (C-layer), an inner layer of hull planking stakes (D-layer), and an outer layer of hull planking (E-layer). Toward the stern, the planking stakes were numbered from east to west as D0 to D6, but additional planking stakes were uncovered beyond D0 to the east and D6 to the west. These additional stakes were given negative numbers D-1 to D-8 to the east and consecutive numbers D7-D12 to the west (see fig. 3-10).¹⁹ The ship had two layers of hull planking extending from its keel to preserved strake 12, which was located six stakes below the gun port (see fig. 3-10, in planking stakes D10-D12). Eight stakes of the E-layer were preserved from strake 1 to strake 12 (E1-E6, E5-E8, and OP1-OP8) (see fig. 3-9). Forty-six frame remnants were numbered (C1-C46) throughout the excavation of the ship (see fig. 3-7). In the foremost section of the hull at the ship's exterior were remains of a layer of pine sheathing (F-layer).

Twelve stakes of ceiling planking (B1-B7, B9-B13) and one shelf clamp (B8) were raised off the seabed (see fig. 3-8). On top of the ceiling planking (B1-B13), remains of small floor beams or laths have been found that were nailed to the ceiling planking to support a pine inner floor, which protected the ceiling planking. At the junction of *Batavia*'s transoms and the side of the ship, massive lodging knees or transom knees (T-layer)

FIGURE 3-15.
Diver attaching an
identification tag
with field number P7A
onto *Batavia*'s inner
layer of hull planking,
strake 14, during
the first excavation
season. Photograph by
Patrick Baker, Western
Australian Museum
(BT-A-0215).



TABLE 3-1. Alphabetical prefix for field numbers of *Batavia* timbers

Alphabetical prefix	Description
A	Knees, deck beams, or other timbers on top of ceiling planking
B	Ceiling planking
C	Frames
D or P[#]A*	Inner layer of hull planking
E or P[#]B*	Outer layer of hull planking
F or SK*	Skin (pine sheathing)
FP	Fashion piece
OP	Outer layer of transom planking
SP	Sternpost
T	Transom timbers
TP	Inner layer of transom planking
TSK	Transom skin (pine sheathing)

* The designations P[#]A, P[#]B, and SK were used only during the first excavation season.

reinforce the interior of the two surfaces of the different planes. They are placed against the transom beams and the ceiling planking at the side of the ship. *Batavia*'s large fashion piece (FP) defined the shape of its stern (fig. 3.14). The transom beams were slotted into dovetail joints in the fashion piece and secured by iron bolts below the transom knees, whereas part of the transom wing was bolted to the fashion piece (T-layer).

The transom beams are no longer connected to the sternpost. The three lowest transom beams nearly touch the side of the endpost, whereas the two upper ones have been worm-eaten and eroded down to two-thirds their original port-side lengths. On the exterior of the transom beams, two layers of transom planking have been preserved. The inner layer of transom planking (TP-layer) runs at a diagonal angle between the sternpost and fashion piece. On the exterior of this inner layer, an outer layer of diagonal transom planking has been preserved (OP-layer). This layer of planking strakes (OP-layer) is nailed to the inner layer, covering the transom, and then runs from the transom to the side of the ship. This planking extends at an angle, varying from 140 to 152 degrees, and cups around the transom and the side of the ship. On the exterior of the transom planking, a layer of pine sheathing, also diagonally fitted (TSK), has been preserved. This layer was not recorded underwater.

The hanging deck knee, lodging deck knee, two fragmentary deck beams, and deck timbers were all given the designation "A." Only a modest number of A-layer timbers were encountered, but complications might have occurred if more of the relatively complex interior deck and reinforcing structure had been preserved.²⁰ These timbers should, in hindsight, have been given separate alphabetical codes in the field that reflected their varying purposes.

Nevertheless, the tags with the alphanumerical system or field numbers are present in the underwater photographs and provide a quick reference while trying to find the location of structural elements on the seabed. Furthermore, the tags were also beneficial as easy references in timber photographs and timber drawings when trying to identify specific pieces.



FIGURE 3-16. *Batavia* hull structure, showing inner layer of hull planking and transom timbers, during the third excavation season. Photograph by Patrick Baker, Western Australian Museum (BT-A-0074).

This method was not applied consistently throughout the three seasons of excavation, as timber prefixes and strake numbers assigned to the forward end do not correspond to the strake number designations of the hull and the ceiling planking in the after end of the preserved hull section (see figs. 3-9 through 3-11). This discrepancy initially caused confusion during study of the hull remains.

As each area was excavated, the hull structure was cleared of coral sand and coral rubble with an airlift, and the fully exposed area was then photographed. Both standard and stereo photography were used to photograph the hull at each stage of excavation. A Nikonos camera was used, with several water-corrected lenses for different circumstances. For all photogrammetry, either a 28 mm UW Nikkor or a 15 mm lens was used. Two ultra wide-angle lenses, a 15 mm UW Nikkor and a 19 mm Canon, were employed for record and illustrative photography, whereas the first lens was specifically used for overall views of the ship's stern. The entire timber area could be photographed in one frame at a distance of 4 m (fig. 3-16).

A photomosaic was made of each timber layer showing the timber in situ, its orientation, its position in relationship to other timbers, and its tag. The timber mosaics were made in a manner similar to the overall site mosaic made in the first season of excavation. For the timber mosaic, each photo taken includes a mobile grid frame. This grid was laid flat on the timbers and then photographed with an approximate camera height

of 2.5 m, which covered an area of 2.4 by 1.6 m and was close enough for fine details to be recorded. Photographs were taken at 1 m intervals, providing a 60% overlap between the photographs. The height of the camera and its tilt were simply judged by the photographer's eye.²¹

TIMBER RECORDING AFTER EXCAVATION

The timbers were registered upon their arrival on land. Each individual piece was given the prefix “BAT”—letters indicating the shipwreck—followed by a four-digit museum registration number. They were stored on Beacon Island in dug-out pits lined with heavy-duty polyethylene sheets and filled with seawater until they were drawn and photographed. The registration books include a brief description of each timber, for example, “hull planking” or “frame.” However, no descriptive catalog entry for each timber has ever been made.

The timbers were then partially cleaned in the excavation camp to remove most of their concretions, and full-size drawings were made by tracing them on plastic film with permanent-marker pens (fig. 3-17). This plastic film was applied directly over the timbers, which caused many difficulties. The material occasionally caused condensation to form, which obscured the drawing surface. In addition, the plastic film easily shifted, resulting in measurement errors, and failed to provide a straight surface for accuracy in tracings. Moreover, the polyethylene film used in drawing these timbers shrank, due to its anisotropic nature, within six years in an irregular fashion because of temperature changes.²²

The full-size timber drawings were later reproduced photographically to a 1:4 scale to make a timber plan. The timber drawings were placed over a 4 by 4 cm grid and photographed. These photographs represented reduced-scale drawings of the timbers. These



FIGURE 3-17. Tracing pine sheathing of *Batavia*'s sternpost on Beacon Island during the third excavation season. Photograph by Lloyd Capps, Western Australian Museum (BT-B-0696).

FIGURE 3-18.

Photography setup for timber recording on Beacon Island during third excavation season. Photograph by ABC Peach's Australia, *The Unlucky Voyage*, 1990, Western Australian Museum.



FIGURE 3-19.

Patrick Baker photographing *Batavia's* timbers with a 35 mm Nikon F camera mounted onto a roof beam of a shed on Beacon Island during third excavation season. Photograph by ABC Peach's Australia, *The Unlucky Voyage*, 1990, Western Australian Museum.



photographically reduced scale drawings have not been used for this study, as full-size drawings are preferable.

Timber plans were made only for the hull planks and frames raised during the first two excavation seasons and do not exist for all timbers. No timber plan was made for any of the pine sheathing or the timbers excavated in the third season—the latter make up a substantial section of the side and transom.

In addition to being traced, each individual timber was photographed in an open-ended shed on Beacon Island, which provided suitable shade from direct sunlight. A 35 mm Nikon F camera was placed 2 m above the ground on a roof beam and focused with a right-angle view finder (figs. 3-18 and 3-19). Timbers were wheeled into the shed on a flat-bed trolley and placed directly below the camera. The camera was mounted so that the film plane was exactly horizontal, and timbers were then leveled using a builder's spirit level.²³ Special care was taken to ensure this parallel relationship between the timber surface and the plane of the camera in order to reduce distortion.

The field view of the camera lens (55 mm Micro-Nikkor-P), however, was not large enough to capture each timber in its entirety. Photographer Patrick Baker then made several overlapping photographs of each timber by moving the trolley in a straight line through the camera's field. These overlapping photographs can then be joined together into one photograph without losing detail and quality. Baker strung a taut white string along lengths of timbers, which proved to be extremely useful for finding the correct orientation and creating a continuous line through various photographs of a timber when

rotating and matching them up. Each photograph included a 1 m scale placed along the upper edges of the plank or timber as well as a small blackboard with the timber's registration number, field number, and thickness of timber. Generally, three or more sides of each timber were photographed. Additionally, a 24 mm Nikkor-N lens was used to obtain single photographs of the complete timber length. Baker noted that extra care was taken in leveling the camera, timber, and meter scale when using this particular lens.²⁴

The photographs taken directly after a timber's excavation, in particular those made with the 55 mm Micro-Nikkor-P lens, have proved to be the most important record of the *Batavia* timbers, as discussed later. After the timbers were drawn and photographed on each side, they were wrapped in polyethylene sheets with an aqueous fungicide solution for transport to Fremantle.

POSTCONSERVATION TIMBER RECORDING

After the conservation treatment was completed on the timbers, their condition was recorded for comparison with their state prior to conservation. They were photographed again and traced at full scale to record features not visible prior to conservation, as well as to correct and double-check the timber drawings made in the field.²⁵ These tracings and photographs were reduced photographically to the same scale as drawings and photographs made prior to conservation so they could be compared for distortion that may have occurred during conservation. The comparison proved problematic due to the shrinkage of the polyethylene film used in the field.

The photography setup was similar to the one used in the field, where a camera was fixed a few meters above the gallery floor to photograph each timber. In this case, a Nikon 35 mm camera with a 105 or 55 mm lens was used.²⁶ The quality of the photographs taken at this stage, however, is not as high as those taken in the field; they are dark and details are not readily visible. Only two faces of each plank and timber were photographed, whereas the field photographs show more surfaces of each timber. Furthermore, the photographic scale was not consistently placed at the same level as the timber surface, so they do not provide adequate dimensions. These photographs have, therefore, not been used in this study.

The timbers were traced underneath a level glass table on top of which acetate tracing film was affixed. The pieces were raised as close as possible to the surface of the glass and then leveled to the same plane as the glass. The outline of each timber, fastening holes, and significant features were drawn on the acetate with permanent markers. Four fluorescent lamps placed under the glass top provided oblique lighting that enhanced specific surface features.²⁷ The acetate tracing film used for this purpose is not subject to non-uniform shrinkage so it provides a more stable record of the timbers than the polyethylene sheets used in the field.

The timber tracings were photographically reproduced with a Toyo 4 × 5 view camera with an 85 mm lens, a large-format camera used to reduce camera lens distortion to a minimum. The camera was mounted at a fixed distance from a wall in the museum gallery on which the tracings were hung.²⁸

REASSEMBLY AND DISPLAY

In preparation for the reassembly of *Batavia*'s hull structure in the Shipwreck Galleries, Paul Hundley and Geoff Kimpton built one research model of the preserved

FIGURE 3-20.
Scale model (1:10) of the
initial design for the
reassembly of *Batavia*'s
hull. Photograph by
Patrick Baker, Western
Australian Museum
(BT-T-0164).



FIGURE 3-21.
Nick Burningham
working on 1:10 scale
model of the *Batavia*
ship. Photograph by
Patrick Baker, Western
Australian Museum
(BT-M-0031).



hull remains at a scale of 1:10, after which Nick Burningham worked on a full model of the ship's reconstruction on the same scale (figs. 3-20 and 3-21). The first model was based mainly on the photomosaics of *Batavia*'s hull structure prior to excavation and the photographs taken of the timbers on the seabed and after being raised.²⁹ Due to lack of funding, the second model still awaits completion.



FIGURE 3-22.
Geoff Kimpton
constructing the
steel backing plate
for *Batavia*'s fashion
piece. Photograph by
Brian Richards, Western
Australian Museum
(BT-T-0223).

In May 1981, the conservation of the fashion piece was completed. After the timber was moved from the dehumidification area into the gallery, a full-size drawing was made and subsequently used for the fabrication of a 1 cm thick steel outline of the timber (fig. 3-22). This template served as a backing plate to support the timber on display and as the outline of the framework for the transom.³⁰ The timber was laid on the plate and bolted to crosspieces on its opposite surface, which functioned as a splint. The encased fashion piece formed the base of the transom reassembly, which was built up from this template (fig. 3-23). It also delineates the outer shape of the transom.

In December 1981, the first of 15 batches of timbers had undergone conservation treatment. The timbers were laid out on the floor of the gallery and rearranged in their position as found on the seabed as if part of a giant jigsaw puzzle (fig. 3-24). The timber plans from the first two excavation seasons and the photomosaics facilitated this process. This process was started over every six months when the next batch of timber came out of conservation.

The final reconstruction began when Kimpton raised the most significant timbers of the hull—the transom and fashion piece—into position in June 1986. Kimpton had designed and constructed a steel framework to support the entire timber assembly. After he had determined how the timbers needed to be supported, he realized that he had to fix the framework in place starting from the aftermost end of the hull to determine its correct shape.

The framework itself is supported by five Royal Steel Industry (RSI) steel pillars, four forming a square encased set and a fifth one placed away from this assembly, that are fixed into concrete supports in the floor and bolted against the wall of the *Batavia* gallery (see fig. 3-23). These load-bearing pillars carry the heavy weight of the display by seating the timber in an open framework that resembles a drawing of a ship's lines. Kimpton designed the framework in such a manner that the timbers can be taken off if necessary for



FIGURE 3-23. Raising the steel framework to support the transom timbers in place in the Western Australian Museum—Shipwreck Galleries, Fremantle. Photograph by Brian Richards, Western Australian Museum (BT-T-0046).

study or conservation treatment. The design is unique as it does not penetrate or tamper with the timbers themselves. It carries the weight of each individual plank as a shelf. In fact, no timbers were altered or damaged in any way during the reassembly of *Batavia*'s hull structure. In addition to each hull plank resting on its own steel batten, the original fastening holes were used to secure the ceiling planking and frames to the two layers of hull planking with galvanized bolts. During the hull's reassembly, a crane moved the timbers into their respective places. In addition, the relatively lightweight sections of the framework that support the ship's side were assembled from temporary scaffolding on wheels.

After the steel supports of the fashion piece and its futtock were finalized, the transoms were placed in their seatings on the fashion piece and a custom-made support of steel was added to the steel backing for the fashion piece. The bolt holes of the diagonal transom planks were used to fit the transom timbers in their proper place. At this stage the bolt holes of the transom knees were also lined up with the beams and transom planking to prevent assembly problems later on. For the transom planking, steel strips 12 mm thick were welded diagonally to the steel frame in between each transom plank (fig. 3-25). After the framework of the transom was completed, it was lifted in place by using pulleys on the steel pillars alongside the gallery wall (see fig. 3-23). The lower end of the transom framework was attached to a 50-ton, load-bearing, high-tensile bolt on the side of the pillars, which enabled the transom to be lifted into position and altered as the structure



FIGURE 3-24.
Sorting *Batavia*
hull planking after
conservation in the
Western Australian
Museum—Shipwreck
Galleries, Fremantle.
Photograph by Patrick
Baker, Western
Australian Museum
(BT-T-0155).

advanced and corrections needed to be made. Both the angle and height of the transom framework could be altered as required.

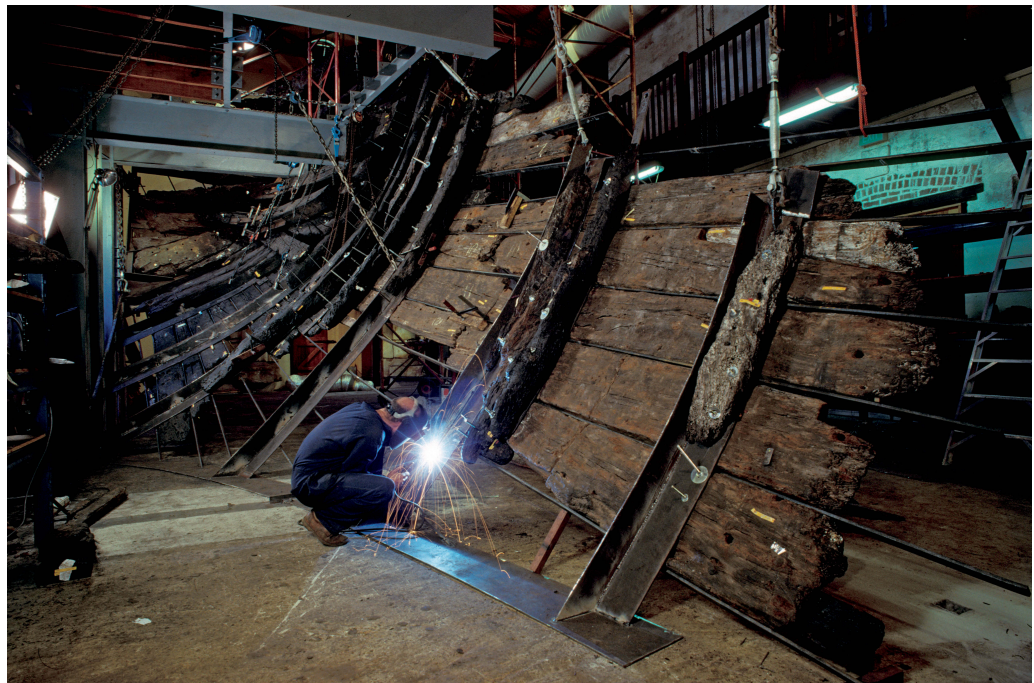
The framework for the side of the ship is constructed on steel strips that support the timbers. A number of frames were selected, for which backing plates were made. These plates form the stationary lines of the framework that are welded to a steel band that runs over the museum gallery floor as a curved pathway (fig. 3-26). Initially, steel cables tightened to temporary crossbeams that extended from the load-bearing pillars alongside the wall held them upright. The crossbeams and cables were eventually replaced by steel rods.

The planks are placed in between flat strips of steel that run along the side of the hull like battens (varying between 2.5 and 5 cm in width and 10 and 12 mm in thickness). These steel battens are seated between each layer of planking and welded to the vertical backing plates of the frames. This assembly takes the main load off the planks. In between the two layers of hull planking, vertical strips run from one batten to another to keep the inner layer of hull planking from leaning against the outer layer. The vertical strips are screwed, not welded, to the edges of the steel battens so they can be removed if a timber

FIGURE 3-25.
Constructing the steel support for the transom planking on the backing plate of the fashion piece and transom beams, Western Australian Museum—Shipwreck Galleries, Fremantle. Photograph by Brian Richards, Western Australian Museum (BT-T-0239).



FIGURE 3-26.
Geoff Kimpton welding the backing plate of the frame to steel battens that support the hull planking, Western Australian Museum—Shipwreck Galleries, Fremantle. Photograph by Patrick Baker, Western Australian Museum (BT-T-0404).



needs to be taken off the display (fig. 3-27). Initially, small vertical lips were added to the edges of the battens (one on top and one on the bottom) to prevent the outer layer of hull planking from falling out. Most of them have been removed, as the 16.75 mm threaded galvanized rods, used in the reassembly to fasten the frames to the hull planking, provided sufficient strength for keeping the outer layer of hull planking in place. The galvanized rods were inserted into selected original bolt holes (fig. 3-28). They were used

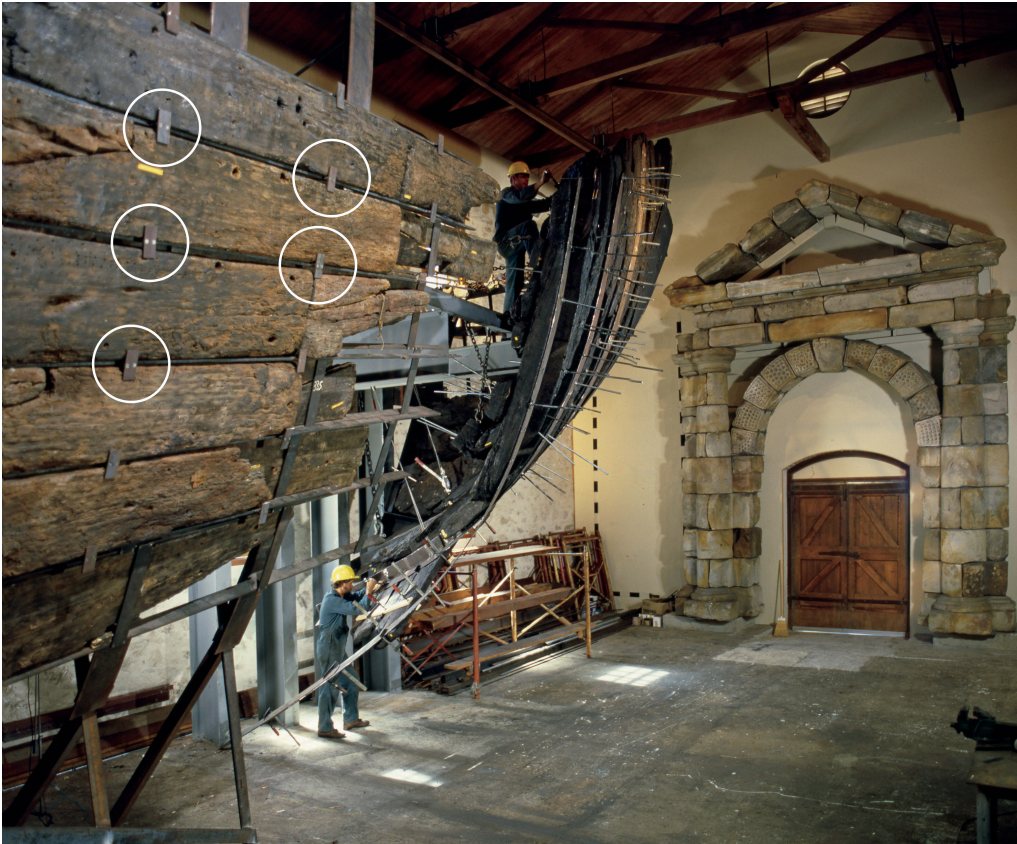


FIGURE 3-27. Vertical strips and stoppers (circles) preventing the hull planks from falling out of the framework, Western Australian Museum—Shipwreck Galleries, Fremantle. Photograph by Patrick Baker, Western Australian Museum (BT-T-0377).

as large screws with a washer and nut on either side of the timber assembly and trimmed to lie flush with the exterior surface after the entire hull was reassembled.

The weight of the entire framework that supports the *Batavia* hull is counterbalanced by seven diagonal steel rods run from the upper gallery balustrade and the load-bearing pillars to the side of the hull, where they are fastened to the backing plates of the frames (fig. 3-29).

The construction of the steel framework that supports *Batavia*'s timbers and the reassembly of the hull timbers began in 1981. The entire operation was eventually completed in 1991, and the *Batavia* gallery officially opened on 16 December 1991.

ORIGINAL HULL SHAPE AND DISTORTION

During the *Batavia* excavation no profile measurements were made underwater due to the site conditions, even though test profile measurements taken in calm seas later proved accurate to within 2 cm. It was assumed that the timbers would maintain their overall shape and curvature, which could then be recorded on land under more favorable conditions.³¹ Therefore, no comparison can be made between the hull shape as found on the seabed and as it stands today in the museum gallery. It must be pointed out that, at the time of excavation, the archaeologists worked to their best abilities and the learning curve was steep, as they had to deal with many complications not encountered previously. Plans of the hull and timber curvature should ideally have been made by conventional methods



FIGURE 3-28. Galvanized 16 $\frac{3}{4}$ mm rods used as screws to hold the planks and frames together, Western Australian Museum—Shipwreck Galleries, Fremantle. Photographs by Patrick Baker, Western Australian Museum (BT-T-0414 and BT-T-0431).

of hull recording when the timber was still underwater. The arrangement of *Batavia*'s timbers can be reconstructed from the underwater photographs of the hull structure, but the actual shape cannot currently be determined from this record. Furthermore, the timbers of the transom assembly make up a structure that is fixed in place and too rigid to be moved in different directions, whereas the hull planking and frames of the ship's side can be pulled and twisted to some extent. Without accurate measurements taken on the seabed, their exact final shape cannot be determined and remains to some degree conjectural.

In fact, the reconstructed hull structure may no longer exactly represent the original hull shape of *Batavia* because several factors could have caused distortion. The timbers may have been deformed to some extent beneath the heavy weight of ballast, cannon, cannon balls, and other materials that covered the ship's hull for more than three centuries. Furthermore, all timbers twist, shrink, and distort to some degree during conservation treatment; on *Batavia* this was particularly true of planks that were bent into shape during construction in the seventeenth century. All of this became evident when recon-



FIGURE 3-29. Interior view of *Batavia*'s hull on display, Western Australian Museum—Shipwreck Galleries, Fremantle. Photograph by Patrick Baker, Western Australian Museum (MA5049-33).

structing the hull timbers in the 1980s. The double layer of hull planking, for example, did not fit together easily. The conserved planks were, however, flexible enough to be bent into their original shape by aligning their bolt holes. This was done over a period of time to a number of distorted planks and frames by continually tightening the new bolts until they provided a perfect fit.

Study of the timbers during their dehydration process before their reassembly has, however, shown that the dimensional shrinkages of the wood were 1%–2% in the longitudinal, 2% in the radial, and 3%–4% in the tangential direction, with an overall timber shrinkage of only $2 \pm 1.5\%$.³² The conservation treatment has, therefore, had only a minor effect on the timbers' distortion.

Finally, some errors may have been made during the reassembly of the timbers. Kimpton, for example, is certain that his reassembly of the hull section was not exactly parallel to the side of the museum building (imagining the side of the building being parallel to the ship's centerline). As a result, the hull structure is supposed to be approximately 50 cm wider at its foremost section than it would have been if he had lined it up properly. When he started the ship's reassembly, Kimpton focused on ensuring that the transom and sternpost were erected in the exact perspective between both sections and did not take the hull's position into consideration in relationship to the side of the building. However, after having taken the lines off the hull and reconstructing them on paper, this error turned out to be nonexistent.

The after three sections of the side of the hull, as excavated, were put together by lining up the fastening holes of the planking, frames, and ceiling planking and following the curvature of the frame timbers. Unfortunately, only a few frames of the original construction were preserved in the foremost section of the hull that was raised during the first excavation season. There are too few of these frame timbers to act as a guideline and facilitate an accurate reconstruction of *Batavia's* original shape. The curvature of the hull in this section is, therefore, an approximation.

Regardless, deformation on the seabed, distortion during conservation, and possible errors made in the reassembly of the timbers are the three factors that may have influenced the current shape of *Batavia's* preserved hull structure. However, the accurate alignment of the bolt and nail holes suggests that the current hull shape should be close to its original form.

HULL STUDY

My study of the ship's hull construction commenced in 2003. Although *Batavia's* timbers were drawn and photographed in the field prior to and again after conservation, the full-scale drawings did not include certain important fasteners. As the surface condition of the timbers was much better immediately after the timbers were raised, a substantial amount of information can be found on the field photographs of the timbers. Biological and physical forces have affected the current state of the timbers and have damaged their surfaces. Some details are only visible on the timbers today, as some parts were not completely cleaned in the field or after conservation. Interestingly, wooden fasteners have become slightly more visible due to differential shrinkage between the fasteners and the planking, a result of the different shrinkage rates in the radial (fasteners) and longitudinal (planks) directions.

Furthermore, not all timbers were drawn, and not all timbers were photographed prior

to and after conservation. The photographs taken prior to conservation provide the most complete record of each individual timber. As previously noted, almost all timbers were photographed in the field, and these photographs were generally more helpful than those taken after conservation. All timbers photographed prior to conservation were leveled to the plane of the camera, the scale was placed level with the face of the timber being photographed, and the quality of the photographs shows each timber at its best. These photos were taken primarily by one person, Patrick Baker, who consistently ensured the highest possible quality. The timber drawings, on the other hand, were made by different people with different levels of experience and training in the recording of archaeological wood, which has resulted in a variety of different drawings. Some drawings are detailed and accurate, whereas others are of such poor quality that they are practically useless.

All timbers were therefore redrawn for this study in AutoCAD on a full-size scale by tracing the timber drawings, which were then checked and corrected against the field photographs made by Patrick Baker and then against the actual timbers. They were checked against the actual timbers only if they are presently accessible and not covered by other timbers in the display. Some timbers were completely redrawn if their respective field drawings were missing or did not provide adequate information such as nail plugs and treenail pegs. The position of each timber in the ship's hull was double-checked with the underwater photography to confirm the accuracy of the timber's location on display. This process demonstrated that the reassembly of the timbers for museum display was very accurate—an outstanding achievement given that Geoff Kimpton had no finalized timber plans.

For this study, the timbers are drawn and represented in their physical shape or state directly after excavation and prior to conservation, as this represents them as closely as possible to their original condition, which makes the reconstruction more accurate. The redrawing of the timbers was started in January 2005 with the scanning of the *Batavia* timber photographic archive in the Maritime Archaeology Department of the Western Australian Museum. Altogether, 4,699 black-and-white negatives taken of *Batavia*'s hull structure underwater and of each individual timber after excavation and 508 color slides of the postexcavation recording and reassembly of the timbers were used to create the ship's full timber plans. These negatives and slides were all scanned in a Tagged Image File Format (TIFF) with a Nikon Super Coolscan 4000 ED at 4,000 dpi to ensure archival quality and maximum visibility of details.

The photographic record of the *Batavia* shipwreck has proven to be the most important and beneficial tool for the reconstruction of the ship's hull, as no timber plan or set of timber plans of the structure was made for each excavation season. Furthermore, some of the tags that carried the timbers' registration numbers had disappeared during postexcavation processing and conservation, and most are obscured now that the timbers have been reassembled; thus, many timbers are no longer numbered. Some registration tags simply got separated from their respective timbers, whereas others had become illegible during treatment by chemicals or iron corrosion. This has been particularly problematic for the study and reconstruction of *Batavia*'s hull. Initially, the main goal was to place all the registration numbers back on the respective timbers. The timber photographs made directly after excavation facilitated this process best. The actual timbers were simply compared to the hundreds of timber photographs until a matching photograph was found.

Sequential photographs taken in the field of one face of a timber using the 55 mm Micro-Nikkor-P lens were joined together using Adobe Photoshop. They include all photographs of large timbers (mainly hull planking, frames, and pine sheathing). It must be noted that the different photographs of each timber often provided a perfect overlay for its outline and all fastening holes and for things such as iron spikes, bolts, treenails, and sheathing nails. This was surprising as it indicates a negligible parallax distortion caused by the camera lens. Furthermore, these timber photos match the full-size timber drawings remarkably well when the two records are superimposed. The outlines of the timbers hardly deviate between one and the other. The fastener and surface details of the drawings and photographs sometimes form a perfect match but occasionally disagree by 5 cm or less.

In addition, all underwater photographs of the hull structure were studied in detail to relocate exactly where each timber came from on the seabed. Both tasks proved to be tedious. The ship's inner layer of hull planking alone took one year of full-time work to figure out the registration numbers of the timbers and redraw them. The new timber drawings were then placed in their original position as on the seabed and the nail or bolt holes of overlaying timbers matched up to determine their correct location within the hull structure.

Although the timber drawings were made as accurately as possible, fasteners may have been missed because they are sometimes obscured by excess PEG or because they cannot be observed in the display where the timbers are covered by others. Additionally, many wooden nail plugs and treenail pegs are not easily detectable and may simply be overlooked. All timber plans are projected onto a flat plane and do not take the ship's curvature into consideration, to show all the features and details as clearly as possible.

TAKING BATAVIA'S LINES

Batavia's hull curvature as displayed in the Shipwreck Galleries was measured and drawn in two days, 17 and 18 February 2008, with the help of Bill Leonard of the

FIGURE 3-30.
Bill Leonard using the
Prexiso laser distance meter.
Photograph by Patrick Baker,
Western Australian Museum.





FIGURE 3-31. Measuring setup for taking curvatures off *Batavia*'s hull, showing leveled x-axis and z-axis beams for taking station lines, Western Australian Museum—Shipwreck Galleries, Fremantle. Photograph by Patrick Baker, Western Australian Museum.

Maritime History Department of the Western Australian Museum.³³ Leonard brought in a Prexiso laser distance meter, which made our exercise easy and saved stretching measuring tapes in a straight line when taking offset measurements (fig. 3-30). This small handheld device measures distance quickly and efficiently within an accuracy of 3 mm. Its measuring capability ranges from a distance of 10 cm to 40 m, and it is operated with

FIGURE 3-32.
 Bill Leonard (*top left*) and the author (*lower right*) taking a distance measurement from the z-axis beam to the hull, from a height of 3.75 m, Western Australian Museum—Shipwreck Galleries, Fremantle. Photograph by Patrick Baker, Western Australian Museum.



a 9-volt block battery. The default reference setting is the base of the instrument, which had to be taken into consideration for taking the offset measurements. All Prexiso laser meter measurements were taken twice, and the deviation between the two measurements was not once greater than 2 mm.

Setting up the measuring system was more time-consuming than taking the actual measurement. First, two parallel baselines, 11 m in length and 5 m apart, were laid out on the gallery floor. The first baseline was stretched along the inside of the five steel pillars that support the framework of *Batavia*'s timbers. These pillars mark the port-side surface of the preserved sternpost (and, thus, that of the keel). From this baseline, the angle of the sternpost and the exact height of the 20 (Amsterdam) ft waterline mark were measured. A 5 m measuring tape was affixed perpendicular to this baseline aft of the transom (= station 0). From here, the lateral and vertical curvature of the wing transom was measured. Scaffolding was placed outside this 5 m line (x -axis) (fig. 3-31), from which a plumb bob was lowered that was held against the wing transom at 50 cm intervals along the 5 m line (x -values). The wing transom points indicated by the plumb bob were marked on a piece of white masking tape on the floor with a permanent marker. Then, the distance

between the mark on the floor and the 5 m baseline was measured with a tape measure (y -value). A large builder's angle was used to ensure a 90-degree angle between the 50 cm interval value on the x -axis and the y -values of the wing transom. From the points marked on the floor, an easy vertical measurement could be taken with the Prexiso laser distance meter from the mark on the floor to the corresponding point on the wing transom, where the plumb bob was being held. This provided a height measurement (z -value) to the wing transom.

After these measurements were completed, a second parallel baseline was measured out from the first to the exterior of the hull, which formed the baseline from which the offsets of the station lines were taken. Ten station lines were measured at intervals of 1.1 m along the second baseline (x -values). Flush against the exterior of the baseline, a stiff pine straightedge, 10 by 5 cm in cross section, was affixed on which the stations were marked (fig. 3-31). On these station marks, another vertical straightedge (z -axis) was positioned and clamped to the scaffolding that was set up behind the baseline. On this straightedge the vertical offset measurements (waterlines) were marked at an interval of 25 cm from the baseline up (fig. 3-32). This straightedge was accurately leveled plumb in both vertical directions with a spirit level to ensure a 90-degree angle between the x - and z -values. Also, great care was taken to align the interior surface of the baseline straightedge flush with the interior surface of the z -axis straightedge to minimize any measurement errors. Subsequently, the Prexiso laser distance meter was placed perpendicular to the z -axis straightedge in a custom-made wooden case to ensure it measured square to the hull in the xy -axis (see fig. 3-30). It also guaranteed that the back of the distance meter, from where the measurements are taken, was seated flush against the interior surface of the z -axis straightedge. The box with the distance meter could be moved up the straightedge to each 25 cm waterline marker to take a y -value measurement to the ship's hull. Each measurement was taken twice to ensure accuracy and to double-check the distance readings.

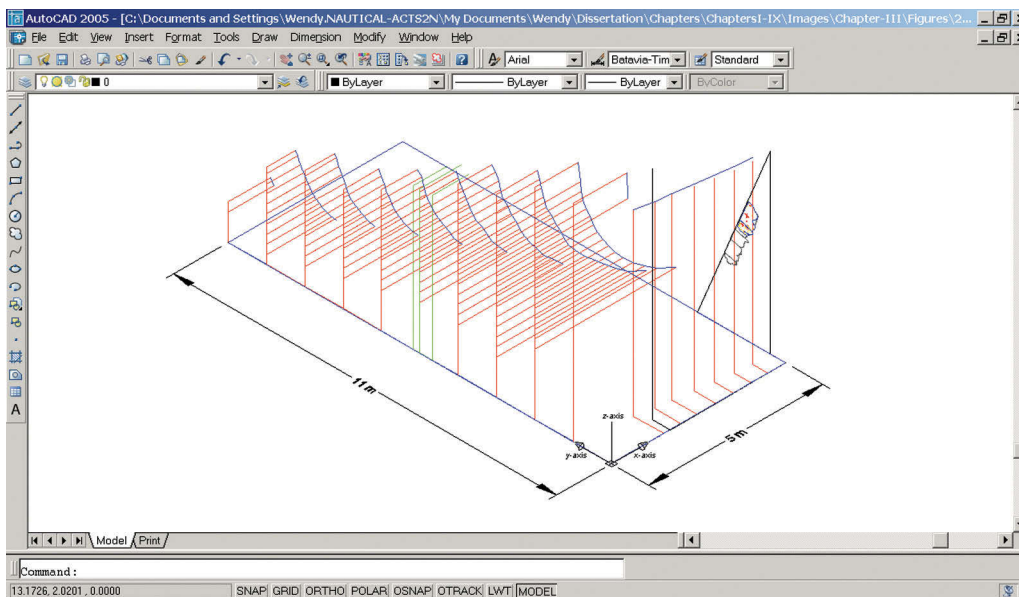


FIGURE 3-33. Screenshot of measurements of *Batavia*'s hull lines entered into AutoCAD 2005 program.

Illustration by author.

In the evenings, all measurements taken during the day were entered and plotted in AutoCAD so they could be redone the next day if errors or other problems occurred (fig. 3-33). It must be noted that all measurements were taken to the outside of the hull. Furthermore, some measurements of the four aftermost stations were taken in places where the outer layer of hull planking is no longer present. In this case, an adjustment needed to be made to correct the difference in planking thickness. Overall, this method has proven to be an efficient and accurate means to take lines of *Batavia*'s after port side and transom.

HULL STUDY AND DESCRIPTION

The VOC Chamber of Amsterdam began the construction of two East Indiamen sometime after the spring of 1626. It is uncertain whether one of these two ships was *Batavia*. They were, however, the first two ships built according to the VOC shipbuilding charter of 29 March 1626. This charter prescribed that, henceforth, the following dimensions had to be applied to the construction of Indiamen: “length within the endposts 160 Amsterdam feet, height of the hold 12.5 Amsterdam feet, the lower or main deck 5.25 Amsterdam feet, and breadth of 36 feet of 11 thumbs per foot.”¹ One Amsterdam foot measured 28.31 cm and was divided into 11 thumbs (2.573 cm).² This entry, recorded in the minutes of a meeting of the Gentlemen XVII, ends with a memorandum stating that the Chamber of Amsterdam would build two new ships as prescribed in the charter. In July and August 1627, the Gentlemen XVII did not discuss construction of ships during their summer meeting, and the following spring they did not gather. It is possible that these Indiamen were the same two ships under construction, one being *Batavia*, at the Amsterdam shipyard in the summer of 1628.³ If not, then it is unknown when *Batavia*’s construction was officially commissioned by the Gentlemen XVII—the sole authority within the VOC to order new ships built. Generally, a VOC ship was constructed in about 18 months.⁴ With a small delay, it could then easily take two years from the decision to construct a ship to have it ready for sea.

CONSTRUCTION HISTORY

In the minutes of the Amsterdam Chamber for 18 November 1627, the Chamber of Zeeland was specifically admonished that it was *not* permitted to construct ships or make changes to the VOC shipbuilding charter without consent of the Gentlemen XVII. The reprimand included the threat of a fine. The construction of ships at the Amsterdam yard is not mentioned in the minutes until 25 May 1628, when two VOC administrators, President Weers and a man named Hasselaer, were sent with shipwright Jan Rijksen to the *vaert* to purchase timber for the construction of two ships in the VOC shipyard in Amsterdam, one of which was *Batavia*.⁵ It is unknown where or what the *vaert* was. The term may refer to the western islands of Amsterdam, known for their timber trade. Here, all timber was transported to the Noorderkwartier. The word *vaart* in Dutch means “canal” or “connective waterway.” The term *vaert* could be seventeenth-century slang or refer to a place outside Amsterdam. As *vaert* is not capitalized in the original handwritten text, it probably does not refer to an official geographic name, and it does not appear on seventeenth-century maps of Amsterdam.⁶

One month later on 29 June, the newly built ships were named: “The large one is resolved to be named *Batavia* [600 tons] and the ship of Major Boom ’s-Gravenhage [300 tons].”⁷ During the summer months of 1628, *Batavia*’s construction had progressed far

enough for the representatives of other VOC chambers to visit the shipyard for an inspection to determine whether construction of the ship was being performed according to the shipbuilding charters.

In the minutes of the VOC meeting that commenced on 18 July, no mention is made by the Amsterdam Chamber of any departures from, or changes to, the 1626 shipbuilding charter in the construction of the new ships.⁸ Interestingly, in the Chamber of Zeeland minutes of the same meeting a scribbled note adds that Rijcksen built the two ships slightly larger, with a depth of 14.0 instead of 12.5 Amsterdam ft. It is not surprising that the Zeeland Chamber representatives took notice of this change, since the Amsterdam Chamber had officially reprimanded them eight months earlier for diverting from the new shipbuilding charter without the consent of the Gentlemen XVII. Furthermore, the Chamber of Zeeland minutes delineate there had been setbacks, following the 1626 charter, during the construction of the two ships in the Amsterdam shipyard.⁹ The general consensus was that no ships would be built any larger than 800 tons and that the height delineated in the 1626 charter should be adjusted to 14 Amsterdam ft, keeping the same length and breadth. What exactly caused the setback in *Batavia*'s construction was not clearly spelled out, but it was probably related to the ship's height. If the construction was delayed, *Batavia* was certainly one of the ships ordered in the spring of 1626. Moreover, the shipbuilding charter of 1626 had obviously caused problems during the building process; such problems would also have surfaced if two ships had been built according to this charter prior to *Batavia*. It is therefore likely that it would have taken more than two years for completion of *Batavia*.

Batavia is mentioned again after its naming, in the minutes of the summer meeting of 1628. The Gentlemen XVII discussed whether it would be possible to have the new ships ready for the next fleet, scheduled to leave in September or October 1628. *Batavia* is listed as the first and most important ship scheduled to sail in this fleet.¹⁰ The construction of the two ships must have been completed soon thereafter, as Jan Rijcksen was commissioned to build the next ship for the Amsterdam Chamber on 18 September 1628. Both *Batavia* and 's-Gravenhage set sail for the first time in the fall of 1628.¹¹

HULL DIMENSIONS, SHAPE, AND RIGGING

The newly built Indiaman *Batavia* was 160 Amsterdam ft (45.30 m) in length over its upper deck and 36 Amsterdam ft (10.19 m) in beam. The height between the top of *Batavia*'s keel and its lower deck was 14 Amsterdam ft (3.94 m), and the height between the lower and upper decks was 5.25 Amsterdam ft (1.486 m).¹² *Batavia*'s length-to-beam ratio was 4.4:1, and its volume, 300 *lasten* (600 metric tons).¹³

It was a flat-sterned ship, like all Dutch Indiamen, with its hull ending aft in a transom and counter.¹⁴ Its forecastle was lower than the aft structure, and heavy wales girdled the ship's sides to provide longitudinal and transverse stiffening. The ship had a relatively shallow draft and a forward-raking, broadly curved stem, and its sternpost raked aft.

The hull planks on the stern narrow slightly but slant significantly, which indicates a full-hulled, flat-floored vessel. The floors amidships probably had only a slight deadrise, creating a flatter bottom and a sharply curved turn of the bilge. *Batavia* had gently curving sides that terminated in a tumblehome amidships. Its shape is different from that of contemporary English ships, which had much rounder bilges and more deadrise amidships. The Dutch had to build their large ships shallower than those of other nations

because the Dutch had to sail them into shallow waters at home and, therefore, tended to construct flat-floored ships.

The *Batavia* hull remains indicate that the ship was constructed using the bottom-based method and was, therefore, typical of early seventeenth-century Dutch shipbuilding. The bottom of a ship was first assembled by fastening the planks together with temporary wooden cleats, after which frame floors were inserted. The temporary cleats were removed as the framework was installed, after which the ship's side planking was fastened to the frames following the frame-first method. The futtocks of *Batavia* were not fastened to each other, which is typical in this construction method.¹⁵ Moreover, rows of small wooden pegs in the lowest preserved planking strakes have provided conclusive evidence for this construction method.¹⁶ The pegs were used to plug nail holes after the removal of the temporary cleats.

Batavia sailed as a fully rigged ship, with additional sails such as a spritsail topsail, topgallant sails, and a mizzen topsail, all of which were introduced in the first quarter of the seventeenth century. Several contemporary representations of Dutch Indiamen demonstrate the VOC's use of such rigs for its large Indiamen at the time *Batavia* was built. Examples include a Dutch Indiaman and its boat on a stained-glass window in the small chapel of the Egmond aan den Hoef castle dating to 1633 (fig. 4-1) and the ships of Pieter van den Broecke's fleet arriving in Holland in 1630 with the first news of the *Batavia* shipwrecking (fig. 4-2). A spritsail topmast and a mizzen topmast are also seen

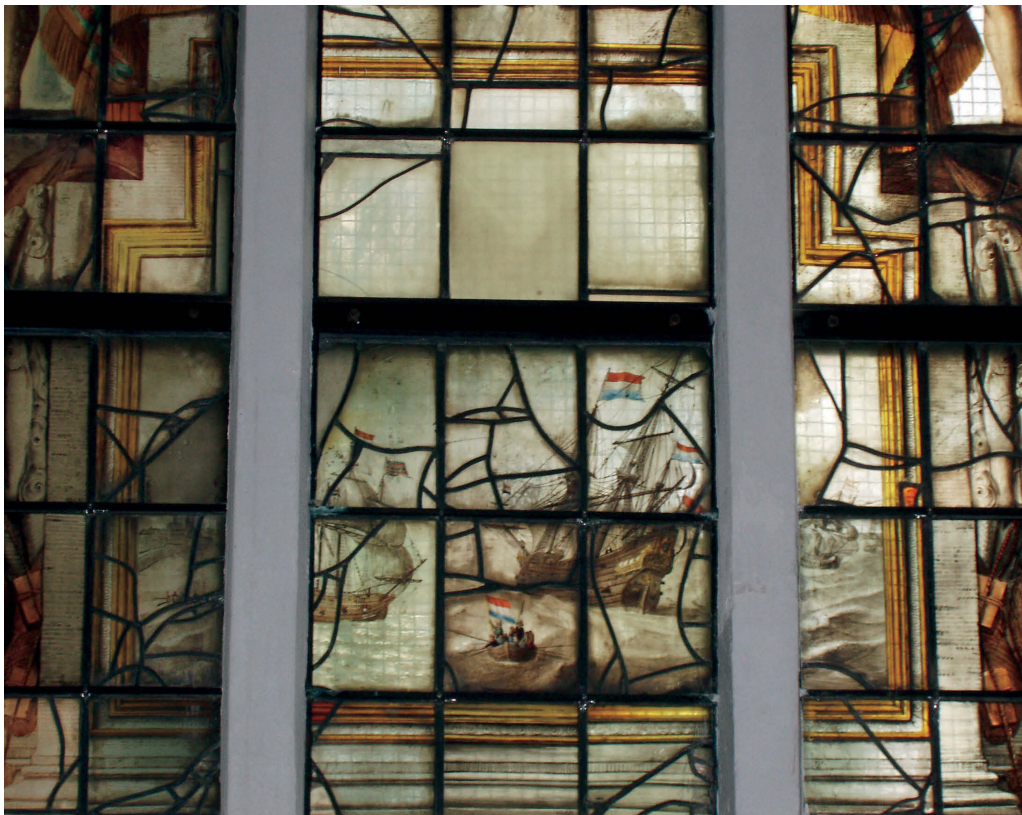


FIGURE 4-1. Ships sailing on the Zuider Sea in the Netherlands, with a Dutch East Indiaman and its boat in the center. Stained-glass window by J. M. Engelsman, 1633, Chapel of the Egmond aan den Hoef castle. Photograph by Johan Knopjes.

FIGURE 4-2.
The VOC fleet of Pieter van den Broecke upon return to the Netherlands in 1630:
(1) *Utrecht*, (2) *Hollandia*,
(3) *Frederik Hendrik*,
(4) *Leiden*, (5) *Wapen van Rotterdam*,
(6) *Dordrecht*,
(7) *Galiasse*,
(8) *Wapen van Delft*, and
(9) *Vergulde Zeepaard*.
Engraving by Adriaen Matham, 1634.



FIGURE 4-3.
Dutch East Indiaman
Salamander, partially
unrigged, built in 1639
by the VOC Chamber of
Amsterdam. Engraving
by Reinier Nooms,
1652–54, Rijksmuseum
Amsterdam (RP-P-
OB-20.528).



on the engraving of the partially unrigged Dutch East Indiaman *Salamander* (1,000 tons), which was built in 1639 according to the same shipbuilding charter as *Batavia* (fig. 4-3).

The exact arrangement of *Batavia*'s decks is not known, but contemporary documents and illustrations offer some insight. Dutch East Indiamen normally had two fully planked decks that carried artillery, cargo, ship's stores, and passengers. VOC ships with three continuous decks were certainly known but did not become common until the late eighteenth century.¹⁷ In the early seventeenth century, they generally had two full decks: the lower gun or main deck and the upper deck (see specifications in appendix A). In addition, their sterncastles had a quarterdeck, which ran from the mainmast to the transom, and a poop deck (figs. 4-4 through 4-7). The forecastle had a deck above the upper



FIGURE 4-4.
A fleet of Dutch East Indiamen, including *Mauritius* (center), passing through the Marsdiep, the waterway between Texel and Den Helder. Painting by Hendrik Cornelisz Vroom, 1600, Rijksmuseum Amsterdam (SK-A-3108).



FIGURE 4-5.
Dutch East Indiaman *Parel* (left), built in 1651 by the VOC Chamber of Amsterdam, and West Indiaman *Dubbele Arent* (right). Engraving by Reinier Nooms, 1652–54, Rijksmuseum Amsterdam (RP-P-OB-20.534).

deck. In between the forecastle deck and quarterdeck was an open space, called the waist, where, among other things, the ship's boat was kept.¹⁸

In the 1647 edition of Francisco Pelsaert's *The Unlucky Voyage*, several engravings of *Batavia* show two rows of gun ports along the side of its hull, suggesting the ship had three or more decks (fig. 4-8). These representations are, however, not part of the original journal and were made specifically for this publication of Pelsaert's story.¹⁹ The ship has 14 gun ports per side in these representations, which matches the number of cannon that *Batavia* carried. *Batavia* has no topgallant sails in the 1647 engravings. Another representation of *Batavia* appears in the 1649 edition of *The Unlucky Voyage* (fig. 4-9). Here, the ship is shown with one row of gun ports and without topgallant sails.

These engravings should be seen as artistic impressions and not true representations of the ship's appearance. First, they were made nearly 20 years after the ship's wrecking. Second, they are not consistent with more detailed and accurate iconography of Dutch



FIGURE 4-7.
Contemporary
model of Dutch
East Indiaman *Prins
Willem*. Anonymous,
1651, Rijksmuseum
Amsterdam.

listed in his overview of salvaged goods as 1 iron cannon of 3,310 pounds and 1 metal (= bronze) cannon of 3,300 pounds.²¹ *Batavia*, therefore, originally carried at least 30 cannon. In a decree of the Gentlemen XVII dating to 22 August 1630, the VOC's large Indiamen were ordered to be fitted with 32 cannon; 24 heavy iron cannon, 6 bronze cannon, and 2 mignons of iron or copper (composite cannon).²² *Batavia* is 2 iron cannon short of what was ordered in the decree.

The large Dutch East Indiamen *Salamander* and *Parel* (1,100 tons) were built by the Chamber of Amsterdam in 1639 and 1651, respectively.²³ Although these particular ships were much larger than *Batavia*, they had one row of gun ports along each side of the vessel, plus one gun port in the transom on either side of the sternpost (see figs. 4-3 and 4-5). *Batavia* probably had a similar arrangement with 14 of its cannon on each side of the lower gun deck and two gun ports at its transom. It would seem, then, that both publications of *The Unlucky Voyage* feature inaccurate depictions of the vessel.

HULL STRUCTURE AND WOOD

Batavia's existing structural timbers, including hull and ceiling planks, are made of oak. The sheathing on the exterior of the ship's hull and the subfloor of the ceiling planking and cargo floor on top of the ceiling were made of pine. A detailed discussion of the use of timber in seventeenth-century Holland and the wood study of the *Batavia*'s timbers can be found in chapter 7. Information on all timbers in the following discussion can be found in the scantling list of appendix B. For this study, only the diagnostic



FIGURE 4-8. Representations of *Batavia*. Engraving from Pelsaert, *Ongeluckige voyage* (Amsterdam, 1647), between pages 2 and 3.

timbers from *Batavia*'s hull were taken into consideration; all nondiagnostic fragments without provenance are excluded.

HULL PLANKING

Batavia's lower preserved hull and its transom are double-planked up to the twelfth preserved strake, which may correspond to the ship's waterline (figs. 4-10 through 4-13). The two layers of hull planking have essentially the same thickness; each strake measures 8 to 9 cm in thickness, with an average thickness of 8.7 cm.²⁴ Thus, the maximum hull planking thickness of the ship's bottom is 18 cm (7 Amsterdam thumbs). The seams of each plank layer are offset by only a few centimeters, which is probably the result of both layers of planking being rabbeted into the keel (fig. 4-14). The maximum planking width varies from 25 cm (strake 4) to 45.1 cm (strake 7), with an average width of 33.9 cm. The longest preserved hull plank is strake 9 of the inner layer of hull planking, which measures 9.72 m (the strakes discussed in this section are illustrated in fig. 4-11).²⁵ This plank is, however, not preserved in its entirety, as the scarf at its forward end only partially survived.



FIGURE 4-9.
Representations of VOC
ship *Batavia*. Engraving
from Pelsaert,
Ongeluckige voyage
(Utrecht, 1649), title
page.

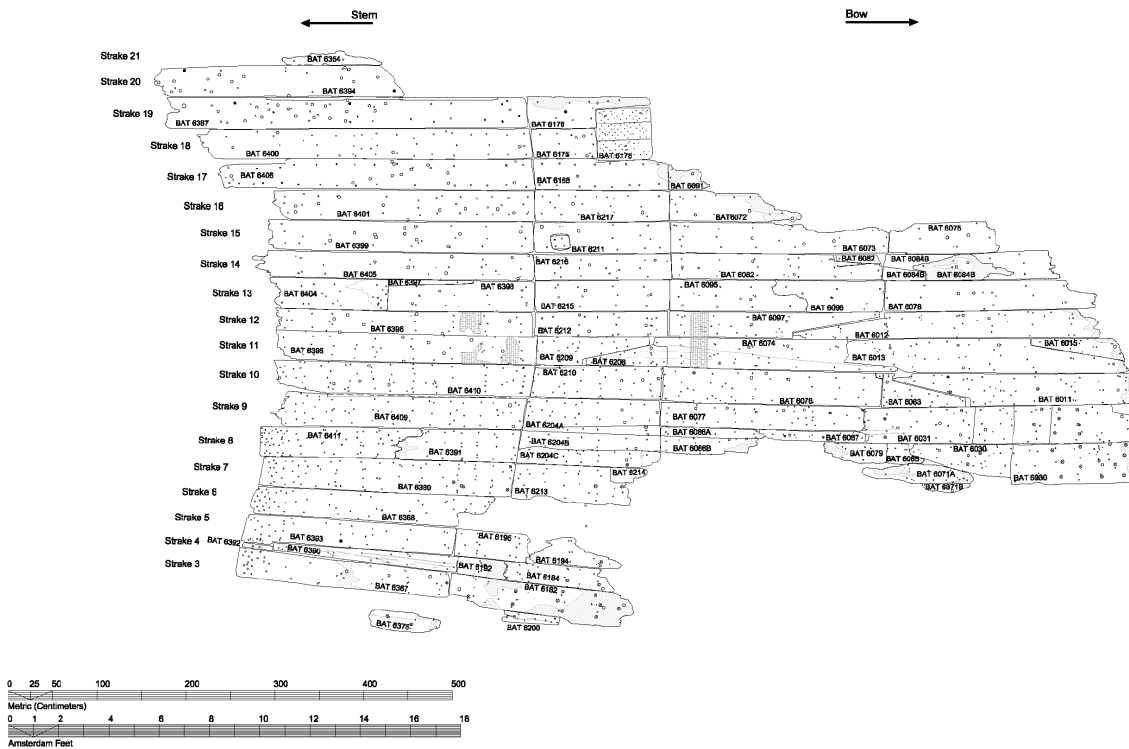


FIGURE 4-10.
Timber plan of inner
layer of hull planking,
preserved strakes
3–21, port side, interior
surface. Illustration by
author.

Strake 13 is the first single-planked layer consisting of two planks joined by a vertical flat scarf. Its maximum width is 35.9 cm, and maximum thickness is 18 cm. In previous publications, this strake has been referred to as the first wale, which seems incorrect as it has the same thickness as the two layers of all the strakes below.²⁶ It does, however, function as a “thick strake of planking,” which is located at the “side of the vessel for the purpose of girding or stiffening the outer hull.”²⁷ Although not physically apparent, it

FIGURE 4-11.

Reconstruction plan of inner layer of hull planking, preserved strakes 3–21, port side, interior surface. Illustration by author.

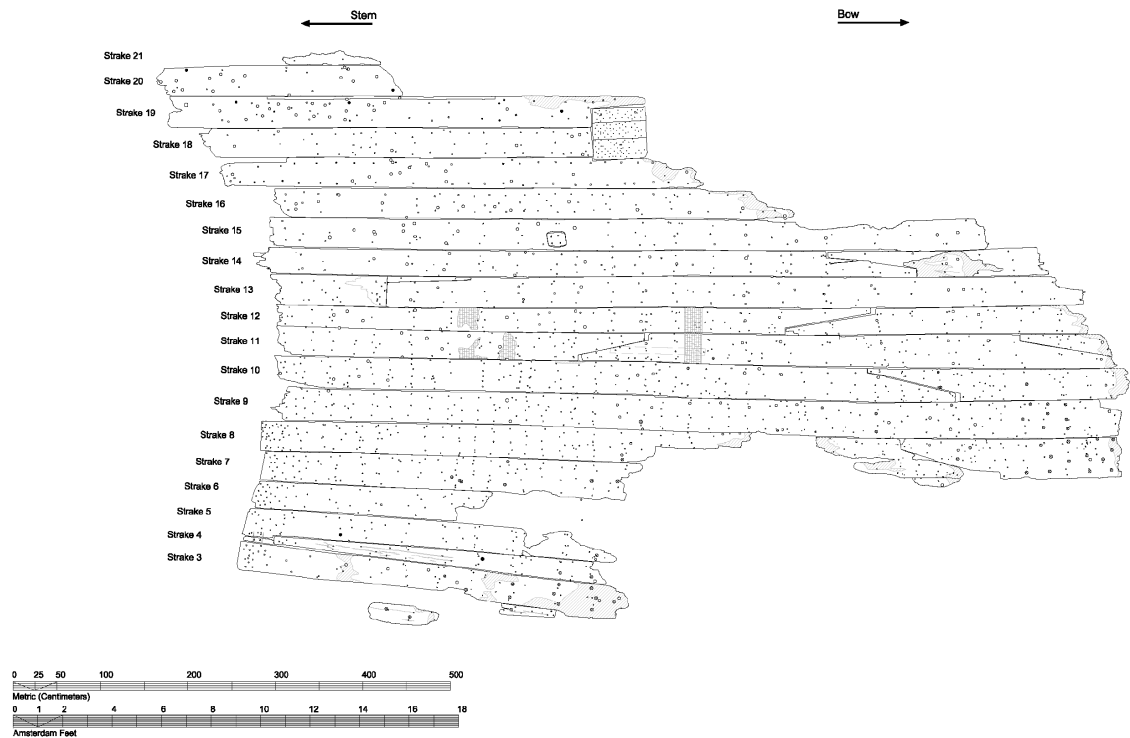
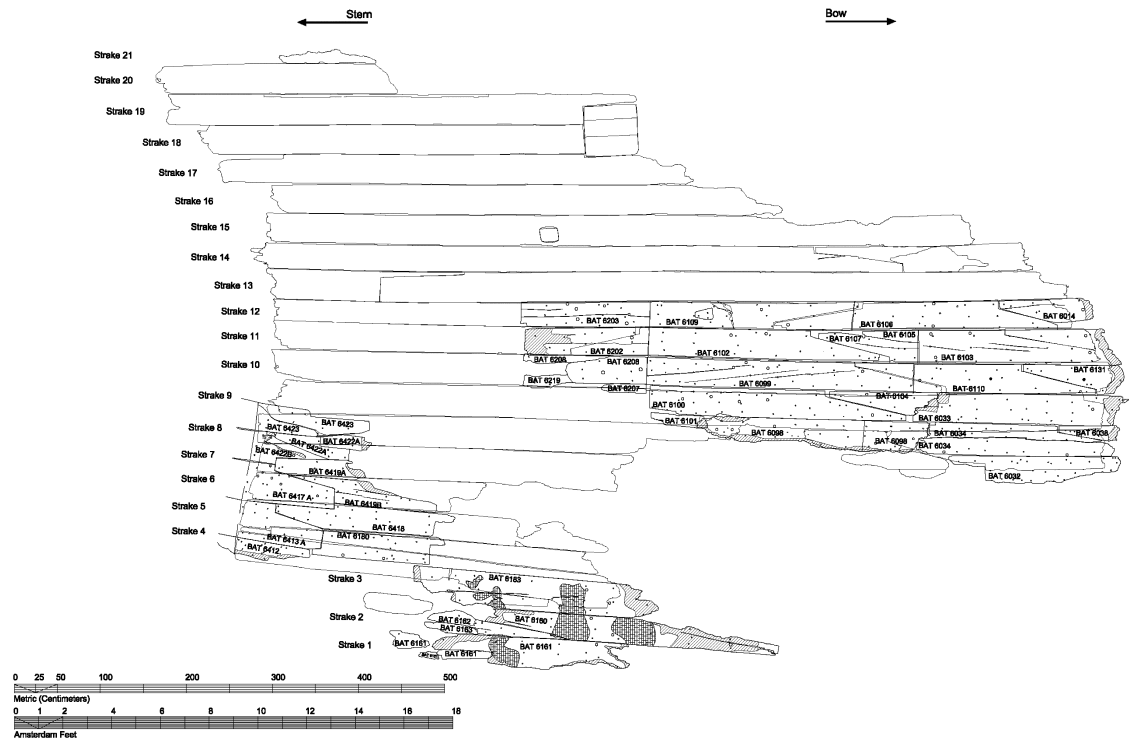


FIGURE 4-12.

Timber plan of outer layer of hull planking, preserved strakes 1–12, port side, interior surface. The inner layer of hull planking is outlined in gray in the background for orientation. Illustration by author.



technically is *Batavia*'s first wale. It also marks the change from the ship's shell-based bottom and frame-based side and probably indicates the ship's waterline.

Above the thirteenth strake, only one layer of planking is applied, though evidence at strake 14 suggests it was double-planked at its forward end. From strake 14 to strake 21, the planking varies from 11.2 to 13 cm in thickness, with an average thickness of 12.5 cm. The two planking layers at the forward end of strake 14 are, however, part of a substantial

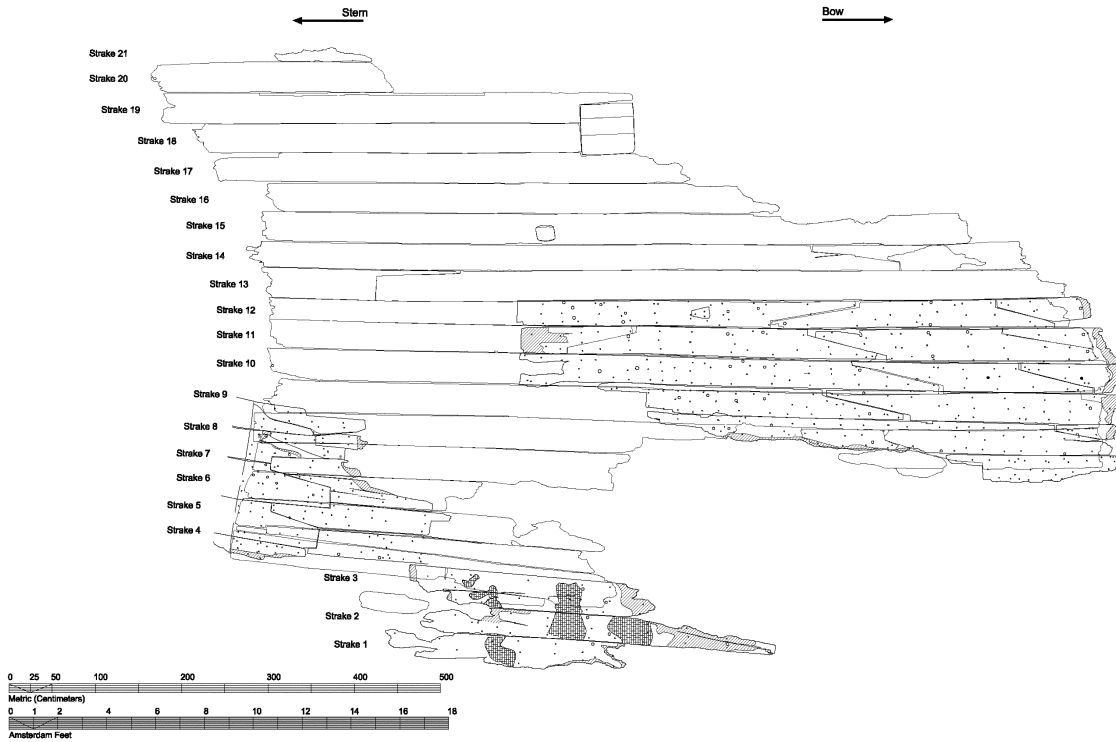


FIGURE 4-13.
Reconstruction plan
of outer layer of hull
planking, preserved
strakes 1–12, port side,
interior surface. The
inner layer of hull
planking is outlined in
gray in the background
for orientation.
Illustration by author.

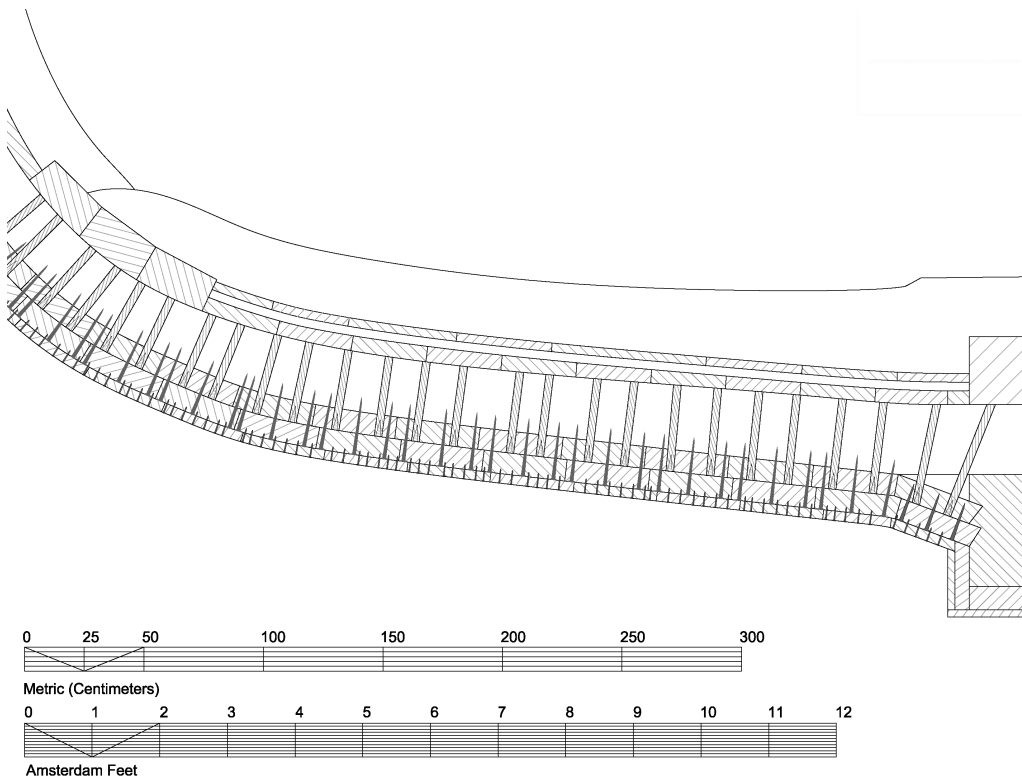


FIGURE 4-14.
Reconstruction plan
of bottom showing
assembly of the pine
sheathing, two layers
of hull planking, floor,
ceiling planking, cargo
floor planking, and
rider. Illustration by
author.

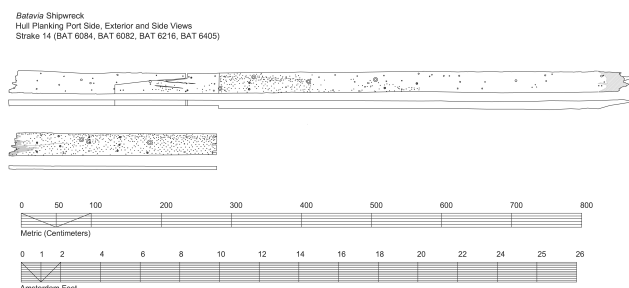


FIGURE 4-15. Hull planking strake with flat scarf and vertical flat scarf. Illustration by author.



FIGURE 4-16. Flat scarf in planking strake 12, exterior of outer layer of hull planking, BAT 6014 and BAT 6106. Photograph by Patrick Baker, Western Australian Museum (MA4864-34).

vertical flat scarf that turns into a single layer of planking (fig. 4-15). The interior end of this scarf comprises two timbers joined by a regular flat scarf. The maximum thickness of strake 14 is 12.5 cm.

In the aft section of the hull, one drop strake has been preserved in strake 4.²⁸ It tapers toward the stern and does not run onto the transom. It is preserved over a length of 3.78 m, tapers from 25 to 9 cm in width, and has a maximum thickness of 8.9 cm. Interestingly, the aftermost end of the plank that is placed above the drop strake, BAT 6393, was apparently damaged in the construction process, and a small insert, BAT 6392, was nailed onto its lower end with two iron nails so it would fit around the drop strake properly.

The planks of double-planked strakes 1–12 and the interior end of the vertical flat scarf in strake 14 are all joined with flat scarfs (fig. 4-16). In the foremost preserved area of *Batavia*'s hull seven flat scarfs are preserved in the inner layer of hull planking and five in the outer layer. The close proximity of these scarfs must have created a weakness in the ship's hull. The complete scarfs of the inner layer of hull planking vary in length from 81.80 cm (strake 11, aft) to 1.08 m (strake 10). Their nibs measure from 5.1 cm (strake 10) to 10.5 cm (strake 14) in width, with an average width of 7.6 cm. The scarfs in the outer layer of hull planking are slightly smaller and vary in length from 71 to 96.2 cm. The dimensions of their nibs are similar to those of the inner layer of hull planking, measuring from 5.1 to 10.2 cm, with an average width of 7 cm.

At first glance, it seems that no scarfs are present in the aftermost section of the ship's planking above the double-planked strakes, but upon closer inspection, vertical scarfs are found in strakes 13 and 14 (see figs. 4-15 and 4-17). These scarfs are best seen from the inside of the hull planking, which is currently not easily accessible because it is mostly covered with frame timbers. These scarfs are used to join the planks of the single-planked strakes of *Batavia*'s surviving hull structure.

The planks of two strakes are thus scarfed together with vertical flat scarfs. Their foremost planks are scarfed onto the outboard surface of the aftermost plank (see figs. 4-15, 4-17, and 4-18). One such scarf is present in strake 13, though poorly preserved and no longer complete, and measures 1.456 m in length (see fig. 4-17). This particular scarf end also has a rectangular graving piece (discussed later). The second vertical flat scarf is

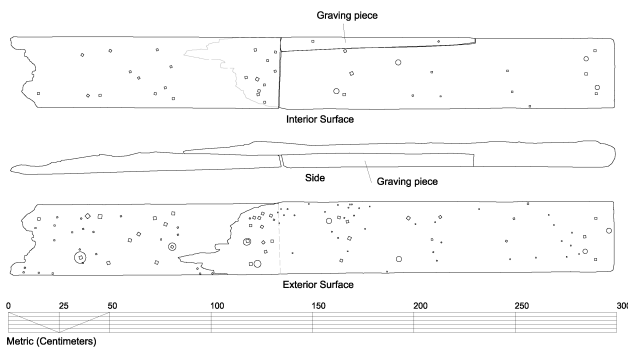


FIGURE 4-17. Hull planking strake 13 with vertical flat scarf, BAT 6397, BAT 6398, and BAT 6404. Illustration by author.

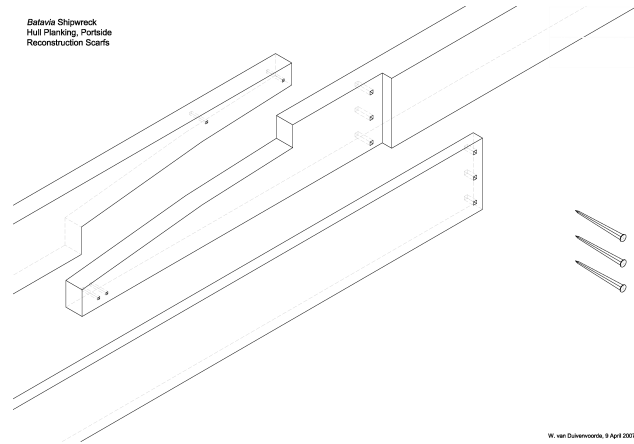


FIGURE 4-18. Isometric reconstruction of planking strake 14 with flat scarf and partial vertical flat scarf. Illustration by author.

situated in the fourteenth strake, from which only a vertical seam is visible at the exterior of the ship's hull. The overlying forward part is fastened to the underlying scarf end with three iron nails (see fig. 4-18). This scarf measures 3 m in length. Vertical flat scarfs are typical for northwestern European shipbuilding and have been found on the archaeological remains of thirteenth- and fourteenth-century coglike vessels, such as NZ43, NZ42, and Q75. They are also visible on iconographic representations of cogs on city seals. The vertical flat scarfs of *Batavia*, however, are much larger and more sophisticated than those of the medieval coglike vessels, which generally varied between 20 and 31 cm in length.²⁹

The frame timbers of the ship's bottom are fastened to the inner layer of hull planking with wooden treenails. Strake 11 is the highest strake in which treenails have been observed. They are absent in strakes 13–18. Strake 12 is the last preserved strake of the ship's bottom that was erected by the shell-based construction method; it may have treenails, but they have not been found to date. The treenails, which had an average diameter of 3.2 cm, fastened not only the hull planking and frames but also the ceiling planking.

Treenails that secured *Batavia*'s frames and planking in place are pegged with square hardwood pegs on their exterior ends (figs. 4-19 and 4-20). These pegs vary in width from 1.5 to 2 cm. In other shipwreck studies, authors have referred to pegged treenails as "wedged treenails," which is incorrect.³⁰ Treenail pegs are seated in the center of the treenails, are square in section, and taper to a point. Treenail wedges are rectangular, flat inserts that span the entire diameter of a treenail.³¹ In seventeenth-century Dutch VOC ships, treenail pegs are generally located at the exterior of the hull planking, whereas wedges are inserted on treenails on the interior of the hull timbers. Due to the poor preservation of *Batavia*'s frame timbers, in particular at the ship's forward end, no wedges have been found to date on the interior ends of the treenails.

At the aftermost end of the bottom hull planking strakes, over an area of 2 m from the transom, frames were not treenailed to the inner layer of hull planking but instead nailed with iron spikes. Most noticeable are the enormous concentrations of iron fasteners where the plank ends were nailed onto the fashion piece. The aftermost ends of the inner layer of hull planking on the ship's side are beveled where they were nailed onto the fashion piece.

FIGURE 4-19.

Fragment of inner layer of hull planking showing pegged treenails, nail holes, and nail plugs, BAT 6375. Illustration by author.

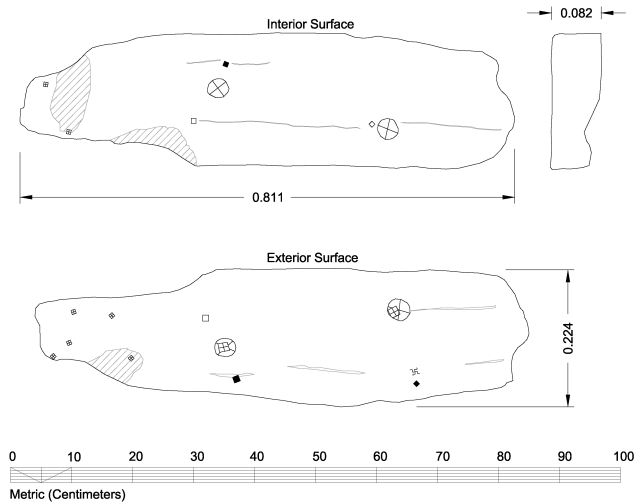


FIGURE 4-20.

Pegged treenail driven from the inner layer of hull planking, as seen on the exterior surface of plank BAT 6375. Photograph by Patrick Baker, Western Australian Museum.



The outer layer of hull planking was nailed to the inner layer, throughout the hull, with iron spikes, with an average of three spikes per plank at an interval of about 20 cm, or basically at each frame. Generally, the nails went through both layers of hull planking into the frames, so their original length must have exceeded 16 cm (see fig. 4-13). The nailing pattern of these spikes in the aftermost section of the hull is regular and may have been facilitated by the slight overlap in planking (fig. 4-21).³²

The single layer of hull planking at strakes 14–21 was also nailed to frames with iron spikes. The shanks of the iron spikes taper slightly in cross section and measure 1.5 cm below their heads. The spike heads vary in size from 2.3 to 3 cm, with an average of 2.5 cm. No treenails were used in the ship's side planking.

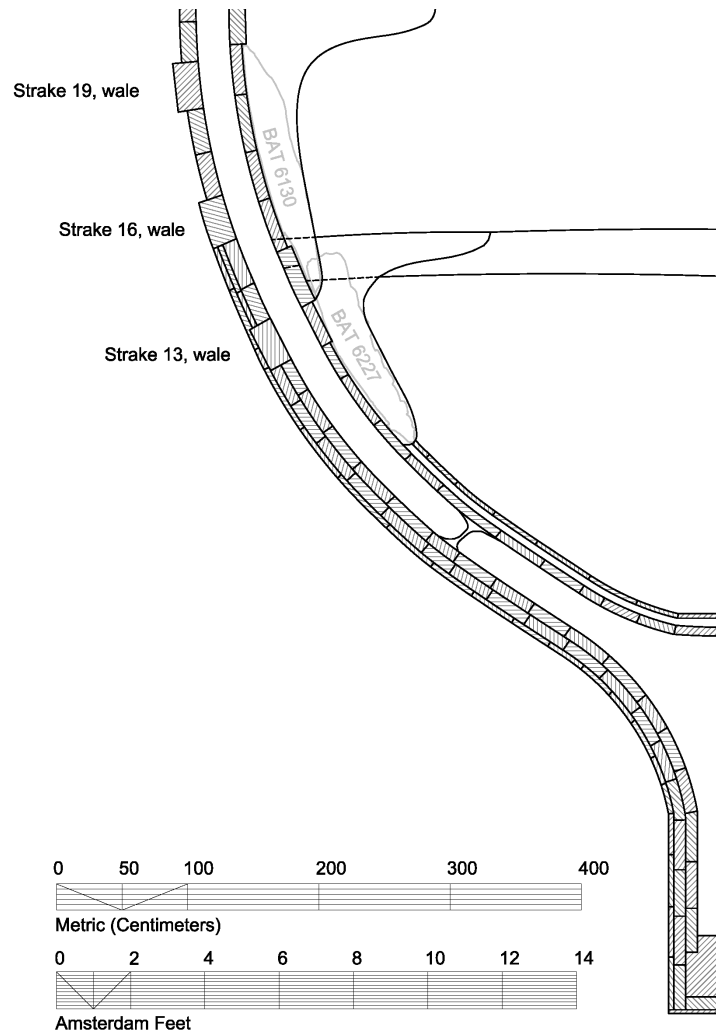
Batavia's planking thickness changes from about 18 cm at its bottom to 12.5 cm on its sides (fig. 4-22). This change is not gradual but rather abrupt. Strake 14 is about 5.5 cm thinner than the thicker strakes below it. The ship's exterior curvature does not continue smoothly at the lower end of this particular strake but forms a straight interruption, a result of the change from a double-planked bottom to single-planked sides. Furthermore, on the exterior face of strake 14, two layers of pine sheathing were applied (discussed



FIGURE 4-21. Nail holes on exterior of inner layer of hull planking directly forward of the transom. Nail head impressions with nail holes are from fasteners that fixed the inner layer to frames, whereas each nail hole next to them are from nails that fastened the outer layer of planking to the inner layer, BAT 6389. Photograph by Patrick Baker, Western Australian Museum.

FIGURE 4-22.

Cross section of hull at frame C31, showing all layers of planking, frames, and hanging knees from lower and upper decks. Illustration by author.



later), probably to compensate for loss in hull thickness and adjust the ship's interrupted exterior surface.

Above the first wale, two additional wales have been preserved. One can be easily identified and is located directly above the surviving gun port (strake 19).³³ It measures 5.485 m in length, has a maximum width of 36.1 cm, and a thickness of 19.3 cm. It may have been slightly thicker originally, as the wale's exterior surface is worn below its original surface. The top of the gun port is cut into the lower forward part of the wale. Strake 16 below the gun port is another wale, although less apparent; it is poorly preserved and worn at its exterior surface. It is, however, still slightly thicker than the hull planking next to it and has a more pronounced shape. It is preserved over a length of 5.98 m, measures 36.1 cm in width, and in some places has a maximum thickness of 15 cm. The original thickness of this second wale may have been the same as that of the ship's first wale, strake 13 (18 cm).

As discussed previously, the outer layer of hull planking is worn toward the transom. The exterior surface of the hull planking near the stern is eroded away below its original surface due to chafing of the hull against the reef. Nail holes from the pine sheathing have

mostly worn away on strakes 8–15 aft of the gun port, although the hull was sheathed up to the fifteenth strake (see figs. 4-12 and 4-13). The exterior layer of planking has been preserved relatively well for about 2 m directly forward of the transom from strakes 3 to 8, and about 4.5 m from strakes 1 to 3.

NAIL PLUGS

Numerous nail plugs, also known as *spijkerpennen*,³⁴ have been found on both the interior and exterior surfaces of the inner layer of oak hull planking (see fig. 4-19, 4-23, and 4-24).³⁵ Nail plugs have been observed up to strake 10, BAT 6011, of the preserved hull planking. They may occur in strakes 11 and 12 as well, but it has not been possible to record nail plugs in these strakes as they are obscured by other timbers or surface damage from sulfur-reducing bacteria. A substantial number of hull planks do not have their original surfaces preserved due to this bacterial activity. The fastening holes left behind by the temporary cleats on the planking have a cross-sectional size of 5 mm, similar to that of the filling nails used to fasten the pine sheathing to the hull planking.

Additionally, nail plugs have been observed in the outer layer of hull planking on the side of the ship that continues onto the transom (see fig. 4-23, BAT 6413). Here, temporary cleats were probably used to prevent the shoring poles from shifting during the ship's construction (see fig. 2-12).



FIGURE 4-23. Two *spijkerpennen* (arrows) inside mortise for a temporary cleat on the exterior surface of outer layer of hull planking directly forward of the transom, BAT 6413, strake 4. Photograph by author.



FIGURE 4-24. *Spijkerpennen* (arrows) on the exterior surface of the inner layer of hull planking directly forward of transom, BAT 6367, strake 3, and BAT 6390, strake 4. Photograph by author.

GRAVING PIECES

Dutch shipwrights working on the construction of large oceangoing vessels would remove knots, cracks, or other irregularities in hull planking and fill the cavities with graving pieces. In *Batavia*'s hull planking, five graving pieces have been observed. Two were used as inserts after the removal of knots, one to patch up a scarf tip, and two to replace a crack or growth aberration along the upper edges of two planks. Similar graving pieces have been found in the hull planking of the Christianshavn B&W 2, Christianshavn B&W 1, and Angra C ships.³⁶

Two of *Batavia*'s graving pieces, inserted to replace knots, were roughly shaped into a quadrangle and a pentagon. The first was found in the hull planking BAT 6211 of strake 15. It measures 21.5 by 13.8 cm and goes through the entire plank thickness of 12.5 cm (figs. 4-25 and 4-26). It was nailed onto the underlying timber with four square-shanked nails measuring a maximum of 1.5 cm in cross section.

The graving piece in the shape of a pentagon is preserved on the outer layer of hull planking BAT 6109 in strake 12. It measures 20.3 cm over its top length and tapers over its width from 13.2 to 5.6 cm. The foremost corners are chamfered, and the lower edge is divided into two faces, measuring 13.9 and 5.9 cm in length (fig. 4-27).

The third graving piece, not visible today, is preserved at the scarf tip on the exterior surface of the inner layer of hull planking BAT 6206 and BAT 6074 of strake 11, seven strakes below the gun port (figs. 4-28 and 4-29). The rectangular wooden insert was probably used to replace a crack or growth irregularity in the scarf tip, because it is too long

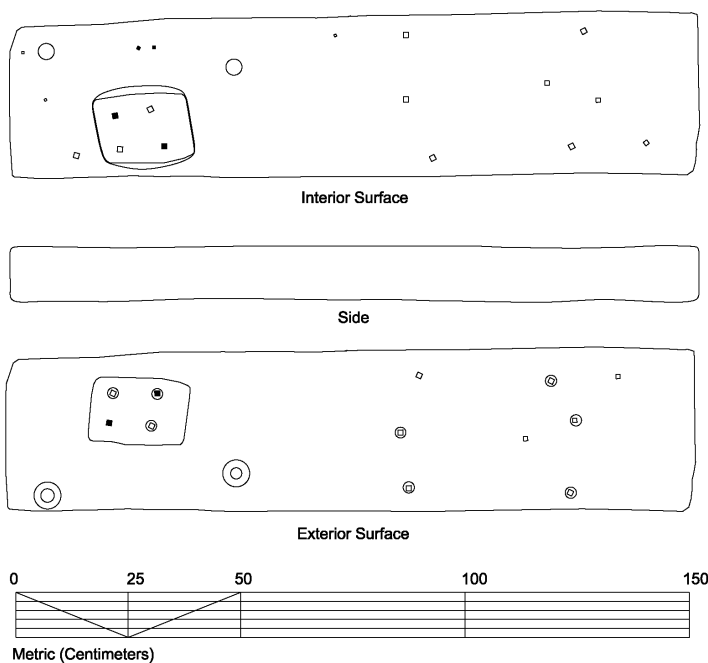


FIGURE 4-25.
Fragment of hull planking with
rectangular graving piece, BAT
6211, strake 15. Illustration by
author.

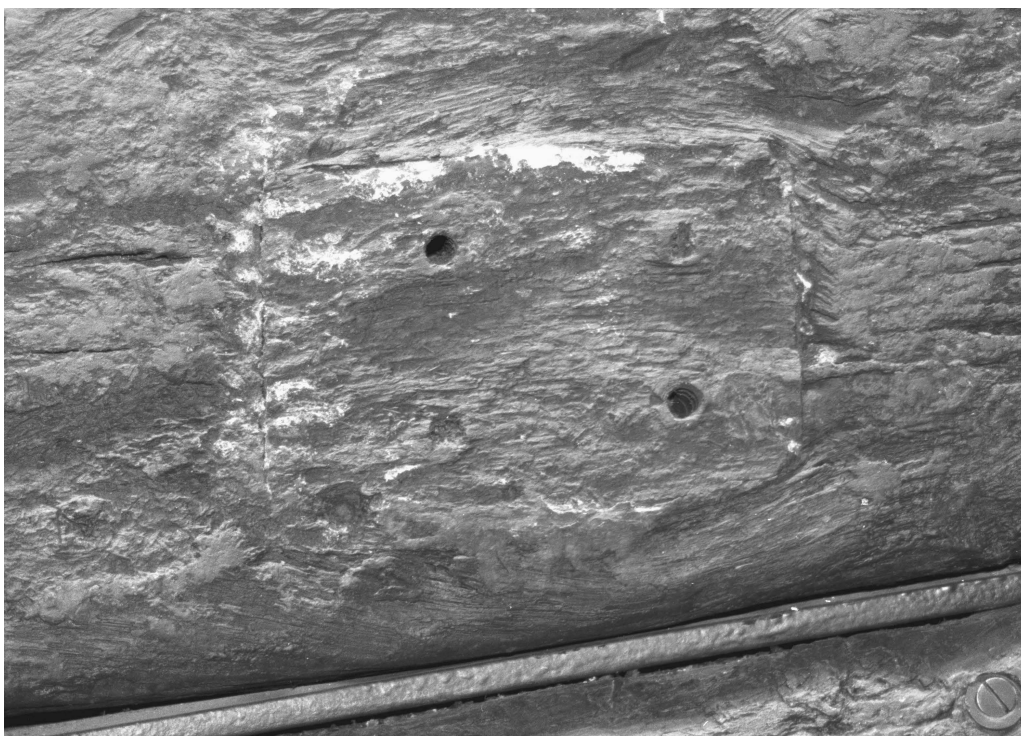


FIGURE 4-26.
Rectangular graving
piece, BAT 6211, strake
15. Photograph by
Patrick Baker, Western
Australian Museum
(MA4864-27).

and narrow to have been used to replace a knot. It measures 1.08 m in length and 7.7 cm in width. It does not replace the entire thickness of the inner layer of hull planking, as it is evident only on the exterior.³⁷ It was nailed to the inner layer of hull planking with five square-shanked nails.

Rectangular strips of wood are found on the top surface of *Batavia*'s third wale, BAT 6367, and on the top surface of the vertical scarf end in the first wale of strake 13, BAT

FIGURE 4-27.

Fragment of hull planking with pentagonal graving piece, BAT 6109, strake 12. Illustration by author.

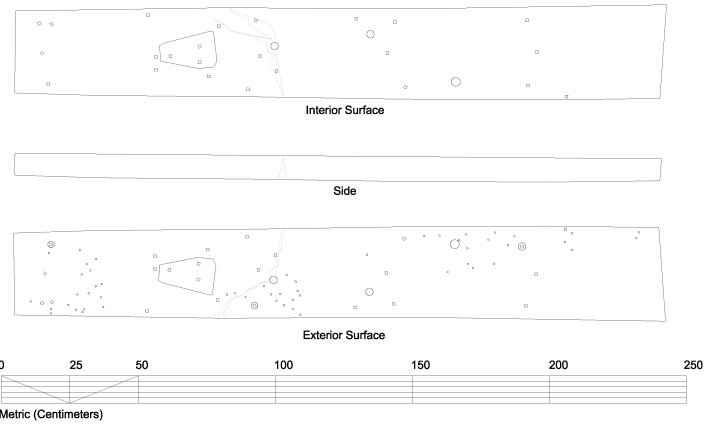


FIGURE 4-28.

Fragment of hull planking with rectangular graving piece, BAT 6206 and BAT 6074, strake 11. Illustration by author.

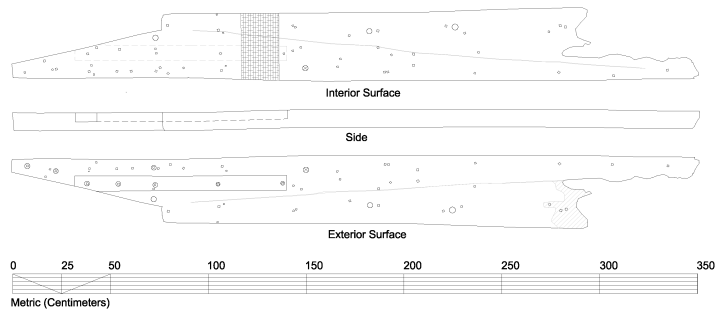
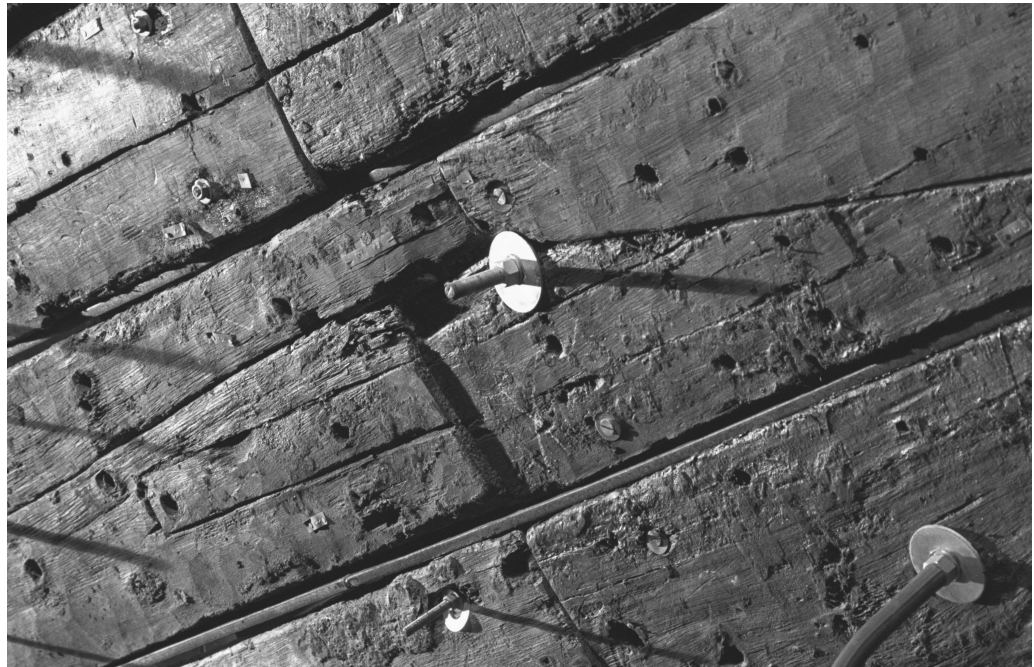


FIGURE 4-29.

Rectangular graving piece forward of scarf end on exterior of inner layer of hull planking, sawn into two sections during excavation, BAT 6206 and BAT 6074, strake 11. Photograph by Patrick Baker, Western Australian Museum (MA4068-10).



6397. On the edge of the third wale, a possible splinter along the timber's edge was removed and two long wooden strips were inserted that are joined together with a small, vertical, flat scarf joint. The two strips together measure 2.52 m in length, 3.2 cm in width, and 6 mm in thickness. On the forward side of the vertical scarf in strake 13, another wooden strip, BAT 6397, was inserted to repair a crack or growth aberration in the plank-

ing. It was secured in place with two iron nails and measures 96.1 cm in length, 7.1 cm in width, and 6.7 cm in thickness (see fig. 4-17).

GUN PORT AND LID

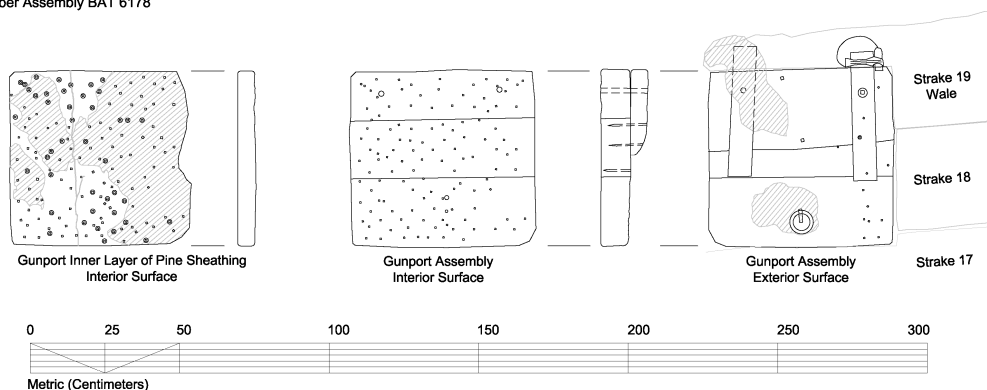
The gun port preserved on the side of *Batavia*'s hull structure is more or less square in shape and is located in the upper part of strake 17, strake 18, and the lower two-thirds of strake 19—the ship's third wale. It is simply cut into the ship's hull planking; no remnants of framing or sills have been observed that would have reinforced and shaped the port and its lid. The remains of a second gun port were found on the lower face of the wing transom (discussed later).

The lid of the gun port on the side of the ship is still present and consists of a complex assembly of three layers of wood. It measures 58.6 cm in height and 61.5 cm in width and fits tightly into the port. The innermost layer of the lid consists of a pine sheathing board that covers the entire area of the lid (fig. 4-30). It measures 5.7 cm in thickness. The board was fastened to the lid's second layer with closely spaced iron nails, with rounded heads and square shanks, in a quincunx pattern. It was applied in exactly the same method as the layer of pine sheathing to the exterior of the hull planking. The circular impressions of the iron nail heads have an average diameter of 1.5 cm, and the nail shanks measure 6 mm square in section directly below the nail head and taper to a point.

The second layer of the lid, which sits flush within the strakes of the hull planking, consists of three thick oak planks fitted horizontally (fig. 4-31). They measure 9.9 cm in thickness and were held together by the sheathing board on the interior. As the gun port is located at the bottom of *Batavia*'s third wale, one additional horizontal plank was fastened to the top exterior surface of the lid to create a continuation of the ship's wale. This top plank, although eroded, measures 6 cm in thickness and 24.3 cm in width. It was fastened to the gun port lid with two large spikes or bolts that ran from the lid's hinges on the exterior to its interior face.

Three concretions were found on the lid's exterior surface; two contained impressions of hinges on the upper half, and one covered the staple and its ring in the center of the lid's lower half. Unfortunately, these concretions are no longer available for study, but they were photographed and sketched in the field directly after excavation, from which

Batavia Shipwreck
Reconstruction of Gunport Lid
Timber Assembly BAT 6178

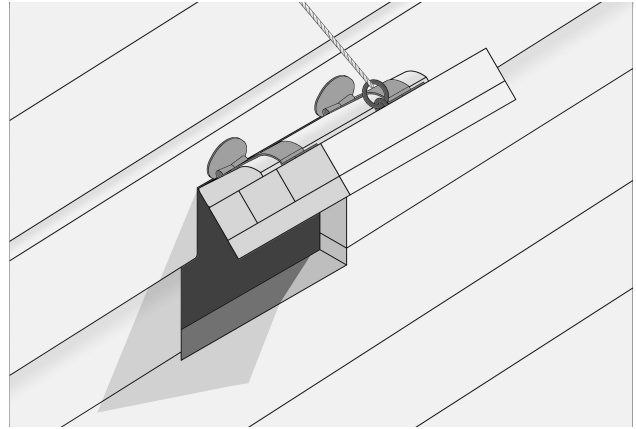


W. van Duivenvoorde, 25 March 2008

FIGURE 4-30. Gun port lid assembly from hull planking strakes 17–19, BAT 6178. Illustration by author.

FIGURE 4-31.

Isometric drawing of gun port lid assembly, BAT 6178. Illustration by Mark Polzer and author.



the reconstruction shown in figure 4-30 could be made. The hinges followed the profile of the exterior surface of the lid and were bent to accommodate the transition between the extra plank on top and the lower half of the lid. A large spike or bolt at the top of each hinge ran through the two layers of oak below. In addition, the hinges were nailed to the lid's exterior surface with several iron nails.

This particular gun port is most likely associated with iron cannon BAT 8722, which was found next to it, broken into three sections. Its starboard side counterpart, BAT 8723, was found nearby. Both cannon are 2.78 m in length and have the same molding.³⁸

TRANSOM PLANKING

The transom planks of *Batavia*'s hull curve in both transverse and longitudinal planes (fig. 4-32). They are not distorted but were cut to create this convex shape, as was the wing transom, which follows this transverse curvature. Furthermore, the scant remains of the sternpost's rabbet line show this longitudinal curvature on the ship's starboard side. The transom was planked, like the ship's bottom, with two layers of oak hull planking (figs. 4-33 through 4-35). These two layers are more or less equal in thickness, like the double layers of hull planking. The thickness of the inner layer of transom planking varies between 9.0 and 10.4 cm, averaging 9.5 cm. The outer layer is slightly thinner; the thickness varies from 8 to 9.4 cm, averaging 8.9 cm. Van IJk mentions that transom planking was allowed to be one-third thinner than hull planking.³⁹ The *Batavia* transom planking, however, does not confirm this practice. The transom planking is joined with diagonal scarfs, and both layers were fastened in place with iron spikes.

The most unusual feature is the outer layer of transom planking at the corner between the transom and ship's side. Here, the planking was roughly cut at an obtuse angle to fit around the inner layer of transom planking and the planking of the ship's side. These curved planks run from the transom over the fashion piece to the ship's side and are scarfed to the side strakes with flat scarfs and to the transom planking with diagonal scarfs. Directly forward of the transom, a concentration of five flat scarfs is evident in the lower strakes of *Batavia*'s outer layer of hull planking.

Eight strakes of outer transom planking survived, of which only the lowest five are curved. These curved corner planks vary from 99.6 cm to 2.36 m in length and from 22.4 to 47.6 cm in width. Their angles, between the ship's transom and side, become progressively smaller from the stern upward. The lowest corner transom plank, BAT 6412, has an



FIGURE 4-32. Port-side transom planking and sternpost. Photograph by Patrick Baker, Western Australian Museum (MA5048-30).

FIGURE 4-33.
Inner layer of transom
planking, port
side, interior face,
corresponding to
preserved outer hull
strakes 3–16. Illustration
by author.

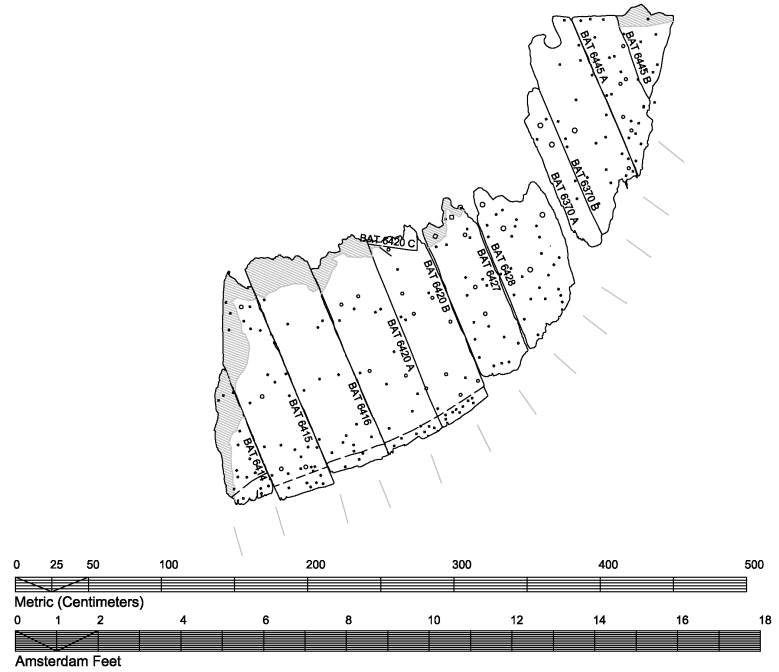
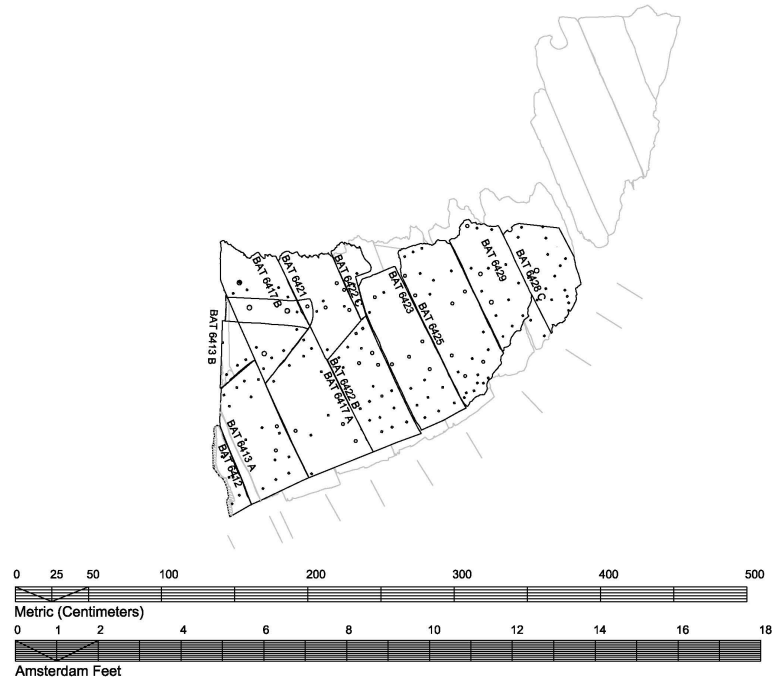


FIGURE 4-34.
Outer layer of transom
planking, interior face,
port side, corresponding
to preserved outer
hull strakes 3–12. The
inner layer of transom
planking is outlined in
gray in the background
for orientation.
Illustration by author.



angle of 152 degrees between two plank ends on its interior surface, whereas the highest, BAT 6423, has an angle of 140 degrees (figs. 4-35 and 4-36). All tool marks from adzes and saws found on these five transom planks indicate that they were carved to create a corner plank (fig. 4-36). The diagonal direction and spread of the adze marks, particularly on the interior surfaces around the plank's bend, clearly indicate that the roughly sawn timber was adzed into shape. Saw marks run in diagonally opposing directions toward the bends in the planks. These tool marks do not provide any evidence to suggest that the sharp angles were a result of bending the planks to create an extreme angle in their centers.

This is in concordance with Van IJk, who recommended the carving of transom plank-

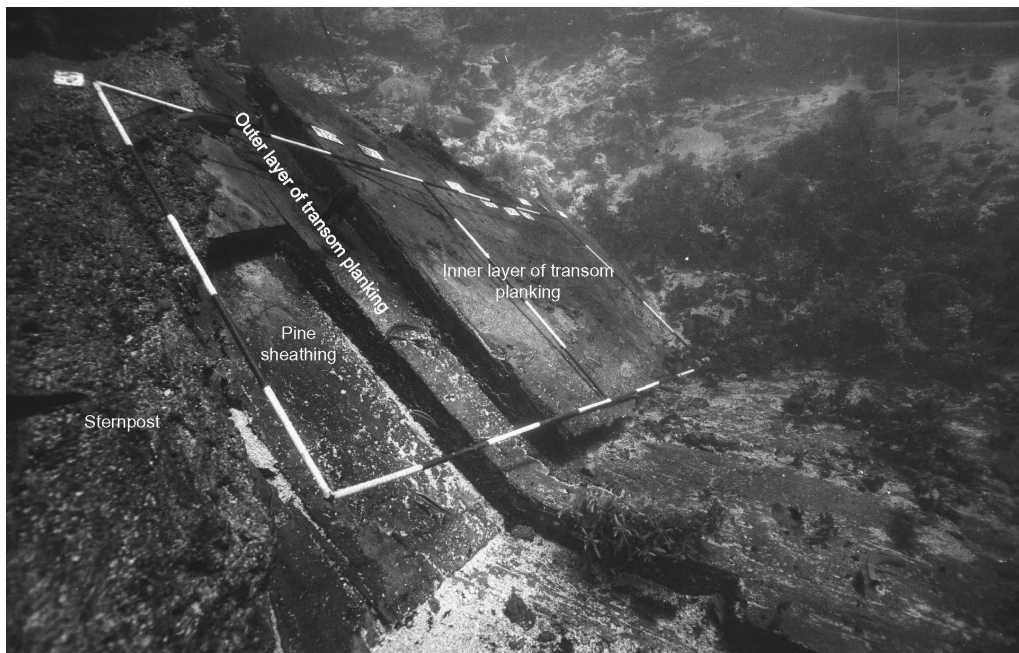


FIGURE 4-35. Inner and outer layer of transom planking on the seabed. Photograph by Jeremy Green, Western Australian Museum (MAO412-22).

ing. Good, smooth pieces of oak were to be sawn into a curved shape with the help of a special mold in order to avoid the aggravation of burning and bending transom planking to achieve the correct curvature, as the transom planking had to be sturdily built. Van IJk had seen this practice in shipyards on occasion and valued it highly.⁴⁰

Eleven strakes of *Batavia*'s inner layer of transom have survived; they were not carved to fit around the fashion piece (see fig. 4-33). The lowest five still have beveled or slanting ends on their exterior surfaces, similar to the beveled ends of the inner layer of hull planking on the ship's side, and all were fastened to the fashion piece with iron spikes. The planks of this layer vary from 19.2 cm to 1.62 m in length and from 15.5 to 51.3 cm in width.

On the interior surface of the outer layer of transom planking a shallow, rectangular mortise was cut to receive the starboard end of the gudgeon (see figs. 4-34 and 4-37). This mortise measures 63.2 cm (2 Amsterdam ft, 2.5 thumbs) in length, 16.7 cm (6.5 Amsterdam thumbs) in width, and 3.8 cm (1.5 Amsterdam thumbs) in depth and flares out, about 10 cm from its end, to 20.1 cm in width. A thick layer of goat hair and a resinous substance were found in the mortise that provided extra waterproofing. The ends of the gudgeons thus extended outward from the sternpost to beneath the outer layer of transom planking, where they were nailed in place with two iron spikes per side. The impressions of the spike heads are clearly visible in the outer layer of transom planking and measure 3.2 cm (1.25 Amsterdam thumbs) in diameter. This demonstrates that the outer layer of transom planking was applied after the sternpost's gudgeons were installed, most likely in the final stage of construction. The outer layer of transom planking around the gudgeon ends was therefore added much later in the construction process than the outer layer of hull planking, which was installed after the frames were inserted. Transom planks BAT 6413 B, BAT 6417 B, and BAT 6421 were probably pre-assembled before they were placed over the gudgeon ends and fastened to the inner layer of transom planking, as three transverse nails were found along the edges of plank BAT 6417 B (see fig. 4-34).

FIGURE 4-36.

Axe and adze marks on the interior surface of transom plank BAT 6423 (*top*); adze marks on the interior surface of transom plank BAT 6413 (*center*); and saw marks on the edge of the transom plank BAT 6417 (*bottom*). Photographs by Patrick Baker, Western Australian Museum (MAO422-26, MAO422-21, and MAO422-32).



CATHOLE, CARDINAL'S HAT, AND BUNG

A circular cathole was cut in transom plank 9 to create an opening through which a cable was passed to tow the ship's boat or to moor the ship. It measures 10.3 cm in diameter (4 Amsterdam thumbs). This cathole was reinforced with a bolster on its exterior surface that was nailed to the transom planking with spikes (see fig. 4-32). This decorative reinforcement, called a *kardinaalsmuts* or cardinal's hat, eased the run of the line and protected it against chafing.⁴¹ The outer width of the bolster measures 32.2 by 36.8 cm (12.5 by 14.5 Amsterdam thumbs), whereas the inner diameter is slightly larger than that of the cylindrical opening (13 cm, or 5 Amsterdam thumbs). Its preserved maximum height is 8 cm.

Since *Batavia* was under full sail and was not towing a boat at the time of its sinking, the hawse hole was plugged with a bung on its interior (fig. 4-38). This bung was still in place during the ship's excavation. It measures 24.8 cm in length, is round in section, and tapers from 13 to 8.1 cm in diameter.



FIGURE 4-37.
Interior surface of
outer layer of transom
planking laid out on
the museum's gallery
floor during reassembly.
Photograph by Brian
Richards, Western
Australian Museum
(BT-T-0199).

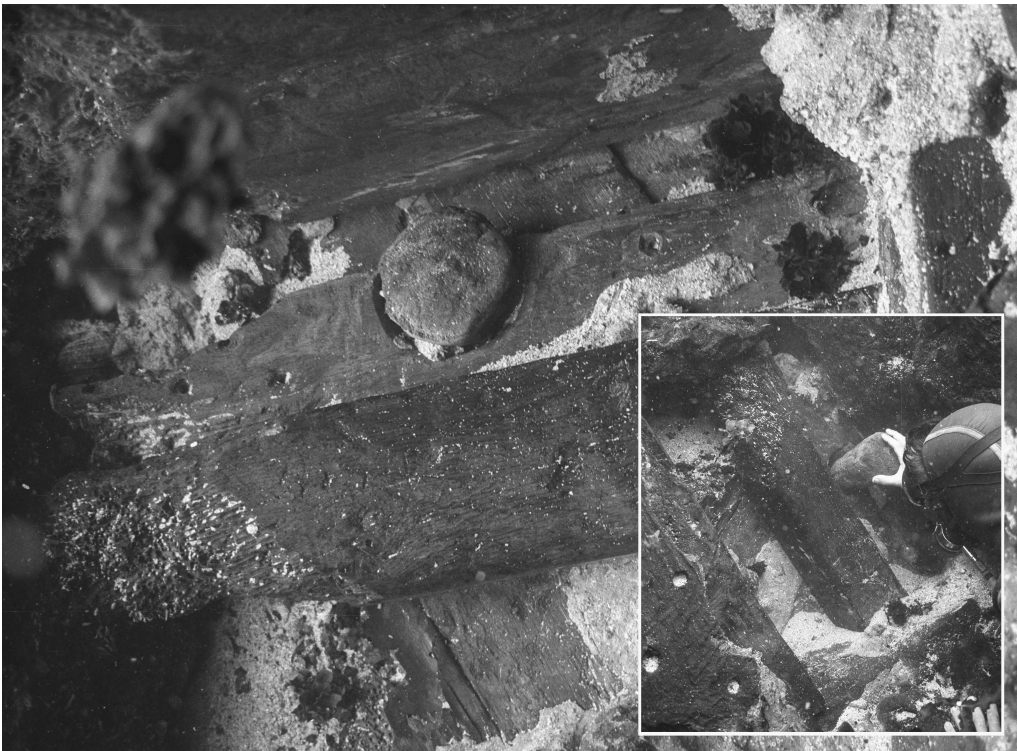


FIGURE 4-38.
Bung from cathole
in the transom, port
side, interior face, BAT
6235. Photographs by
Patrick Baker, Western
Australian Museum
(MA0289-17 and
MA0289-23).

PINE SHEATHING

Batavia's hull was sheathed with pine planking, up to at least its fifteenth preserved strake (figs. 4-39 and 4-40). The pine sheathing has a maximum thickness of 4 cm. Some fragments of the sheathing that were poorly preserved on the seabed have been preserved at the forward ends of strakes 12–15. These fragments, some originally belong-

FIGURE 4-39.

Timber plan of inner layer of pine sheathing, preserved strakes 12–15, port side, interior surface. The inner layer of hull planking is outlined in gray in the background for orientation. Illustration by author.

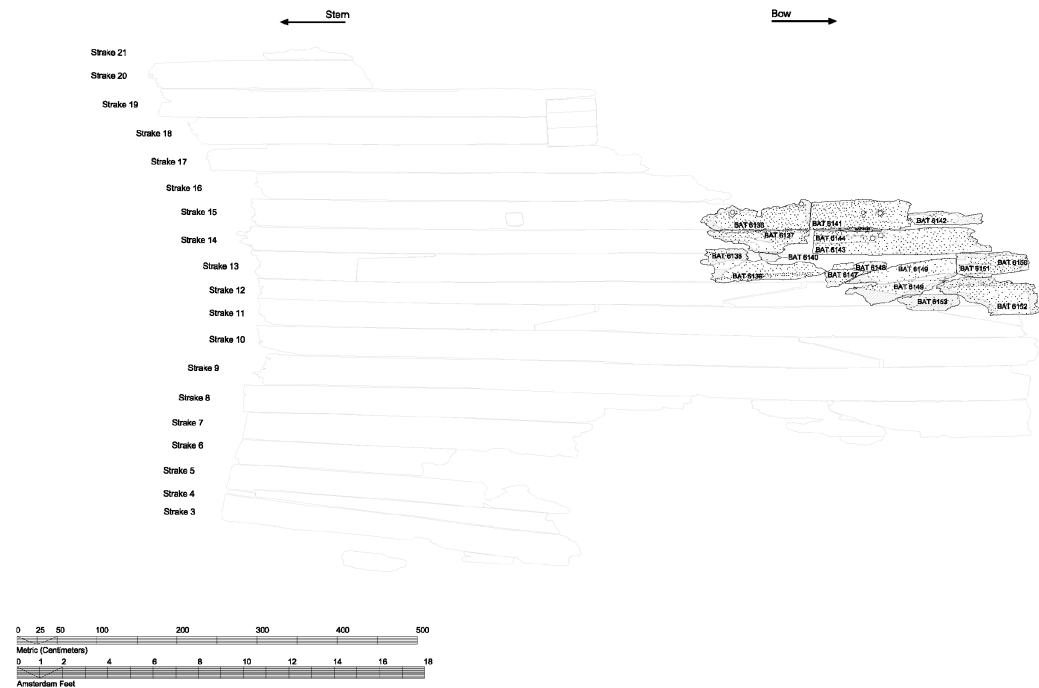
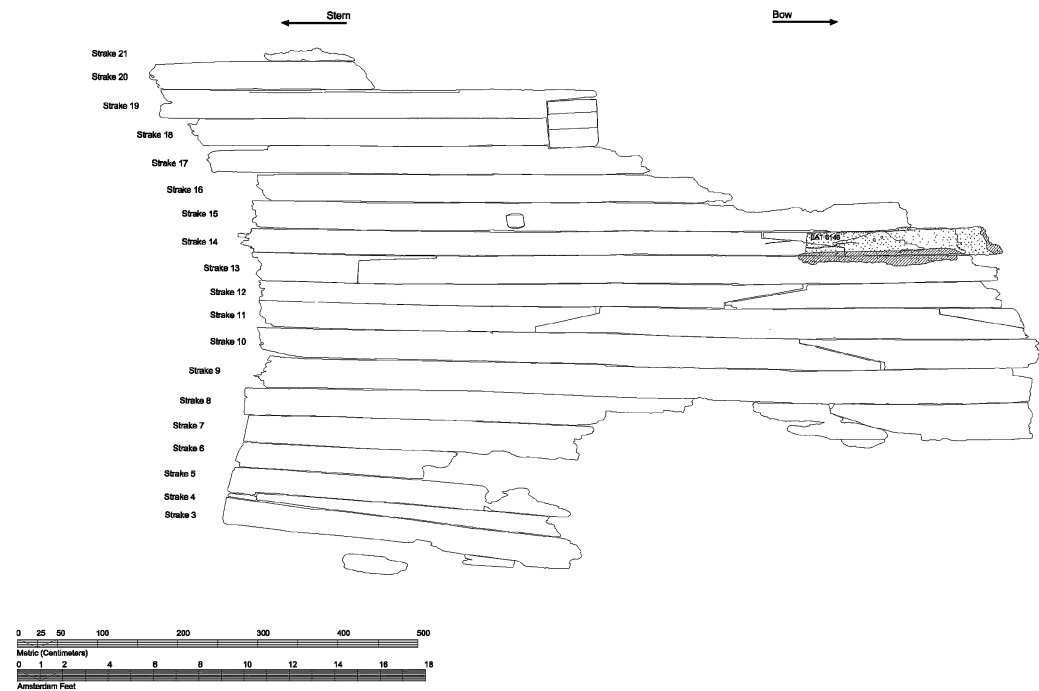


FIGURE 4-40.

Timber plan of outer layer of pine sheathing, preserved strakes 13–14, port side, interior surface. The inner layer of hull planking is outlined in gray in the background for orientation. Illustration by author.



ing to the same plank, vary from 27.7 cm to 2.55 m in length and from 12.5 to 53.6 cm in width. The pattern of the sheathing or filling nail holes preserved on the exterior of the outer layer of hull planking clearly shows the edge fastenings of the pine sheathing planks. No pine sheathing has been preserved from the after two-thirds of the hull. Furthermore, the poorly preserved remnants of closely spaced nail holes from the filling nails in the exterior surface of planking in this area of the hull indicate that the original exterior sur-



FIGURE 4-41. Nail holes with nail head impressions and some goat hair on the exterior surface of pine sheathing, BAT 6241. Photograph by author.

face of hull planking is no longer present. It is unknown up to what strake *Batavia*'s hull was sheathed in pine, but no pine sheathing or associated nail holes in the hull planking have been observed above strake 15.

On the exterior surface of strake 14, two layers of pine sheathing were applied, most likely to compensate for the loss of 5.5 cm of hull thickness between strakes 13 and 14. It adjusts discontinuity in the ship's exterior surface. The inner layer of pine was 4 cm thick, whereas the outer layer tapered in thickness from the center to its seams (see figs. 4-39 and 4-40).

The pine sheathing was attached to the exterior of the outer layer of planking with iron nails that were closely spaced to produce an iron rust layer that protected the hull against marine organisms.⁴² The square nail holes in the pine sheathing and on the hull planking indicate that the nails were fastened at intervals of about 5 cm, in a quincunx pattern (fig. 4-41). The circular impressions of the iron nail heads have an average diameter of 1.5 cm, indicating that the heads were not particularly large.

The pine sheathing remnants at strakes 14 and 15 show that round holes were cut in the planks, varying from 5.1 to 6.4 cm in diameter, to fit the sacrificial planking neatly around the heads of large iron bolts that probably fastened the ship's riders to the ceiling planking, frames, and hull planking (see figs. 4-39, 4-40, and 4-42). Iron filling nails were spaced neatly around the holes that seat the bolt heads.

Numerous pine sheathing planks were found on top of the well-preserved transom planks. The nail holes on the exterior of the transom planks indicate that the iron filling

FIGURE 4-42.
Interior surface of pine
sheathing plank BAT 6141,
strake 15. Note sheathing
nails spaced neatly around
bolt head holes. Photograph
by Patrick Baker, Western
Australian Museum
(MA0199-27).



FIGURE 4-43.
Layer of pine
sheathing on
transom planking,
port side, interior
face. Inner layer of
transom planking
is outlined in gray
in the background
for orientation.
Illustration by
author.



nails were 6 to 7 cm in length, their nail shanks were 5 mm in cross section, and their heads measured 1.5 cm in diameter. The heads of all filling nails were slightly rounded at their tops. Although most of the pine sheathing planks from the transom were not recorded or mapped in situ, they ran diagonally like the transom planking (fig. 4-43). Their dimensions are similar to those of the pine sheathing of the ship's side.

LAYERS OF GOAT HAIR

Thin layers of animal hair, approximately 5 mm in thickness, were applied to the outboard surfaces of the two layers of *Batavia's* hull planking (fig. 4-44). Some hair was also found on the outboard surface of the pine sheathing on the sternpost (see fig. 4-41). This layer will simply be referred to as hair to be consistent with the terminology used in nautical documents dating to the seventeenth century.⁴³ The layer of animal hair between the planking and sheathing was mainly intended to be a bulking agent for the tar, to deter wood rot, and to keep teredo worms from boring into the bottom planking.

Excavators tentatively identified and published that the layers of *Batavia* hair consisted of "cow hair" payed on the ship's hull with tar.⁴⁴ Recently, seven samples of hair from this layer have been identified as goat hair (table 4-1). These samples were sent for species identification to the Research and Consultancy Service for Biological Archaeology and



FIGURE 4-44.

Sample of goat hair from the hair layer between the inner and outer layers of hull planking, BAT 4123. Photograph by Patrick Baker, Western Australian Museum (BT-46-23).

TABLE 4-1. Results of hair identification from *Batavia* timbers

Catalog number	Source of sample	Species
BAT 4123	Frame area, aftmost hull section	<i>Capra hircus</i>
BAT 6240	Sternpost sheathing (inside), starboard side	<i>C. hircus</i>
BAT 6241	Sternpost sheathing (outside), starboard side	<i>C. hircus</i>
BAT 6249	Sternpost cover planking (inside), starboard side	<i>C. hircus</i>
BAT 6439	Sternpost cover planking (inside), port side	<i>C. hircus</i>
BAT 6441	Sheathing from transom (sacrificial planking)	<i>C. hircus</i>
BAT 6442	Tar and hair from shipwreck site (loose find)	<i>C. hircus</i>

Source: Identification by Henk van Haaster, BIAx Consult.

Environmental Reconstruction in the Netherlands (BIAx Consult). These specialists are trained in the identification of archaeological animal hairs from northwestern Europe and are also equipped to obtain micrographs of the hairs that can be verified by other biological archaeologists or specialists. All hairs from these two samples were identified as goat hair. The diagnostic features of goat hair are clearly visible, and some of the seven samples are remarkably well preserved considering that they were on the seabed for more than 300 years. The cross-sectional outline of the hair is dumbbell shaped, characteristic of the hair of goats, rabbits, and hares. Goat hair, however, also has a distinct medulla pattern referred to as “scaloped” or a “honeycomb lattice,” which is clearly visible in figure 4-45. This medulla nearly fills the entire hair, which results in a thin cortex.⁴⁵

Animal coats consist of two types of hairs: guard hairs that form the outer coat, and fur or wool hairs that form the inner coat. Hair specialist Henk van Haaster explains that only guard hairs have diagnostic features that allow for identification of a particular animal, whereas the so-called fur hairs have no diagnostic markers.⁴⁶ Fur hairs from one

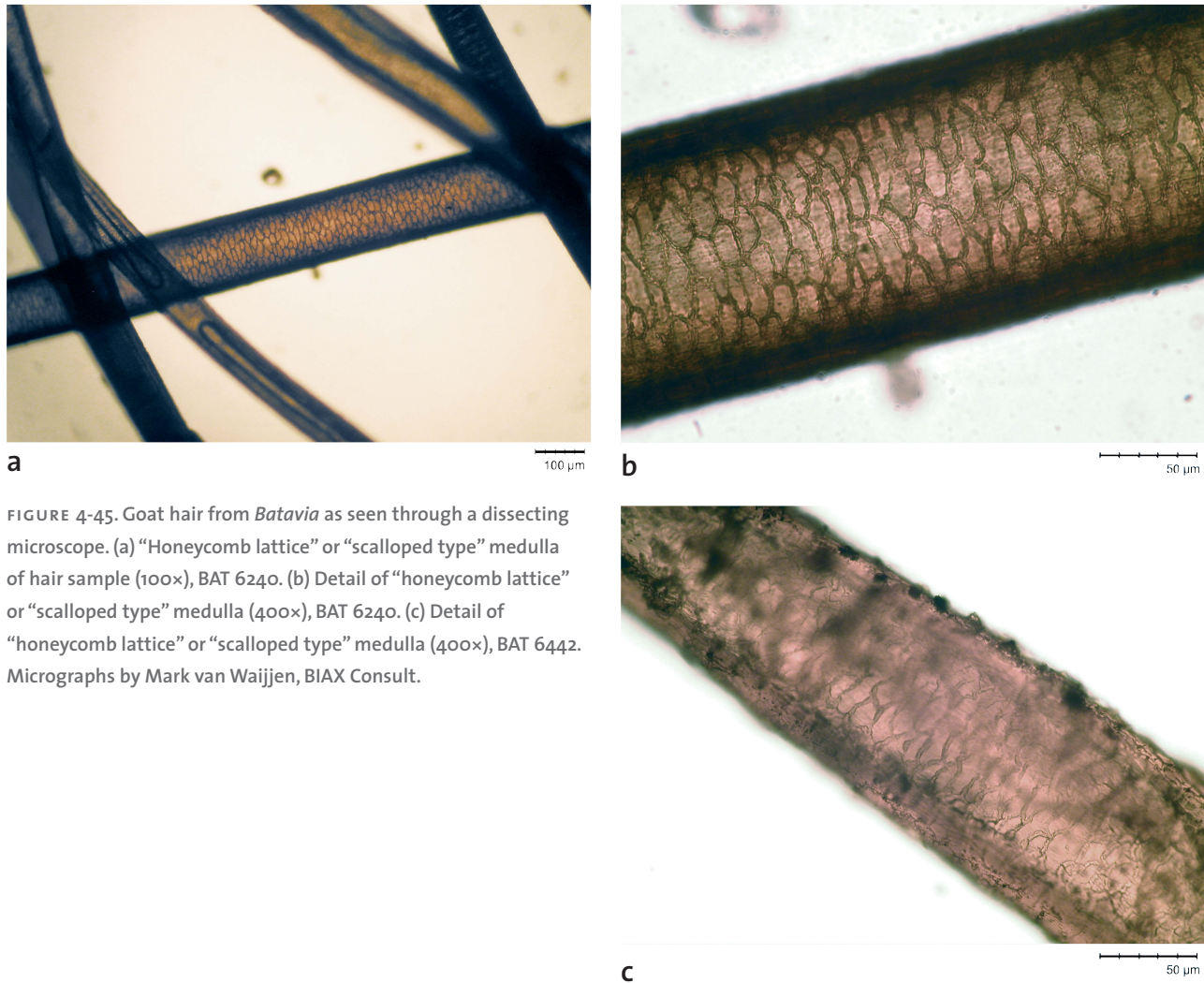


FIGURE 4-45. Goat hair from *Batavia* as seen through a dissecting microscope. (a) “Honeycomb lattice” or “scalloped type” medulla of hair sample (100×), BAT 6240. (b) Detail of “honeycomb lattice” or “scalloped type” medulla (400×), BAT 6240. (c) Detail of “honeycomb lattice” or “scalloped type” medulla (400×), BAT 6442. Micrographs by Mark van Waijjen, BIAAX Consult.

animal can easily be mistaken for the hair of another if not examined by an experienced or trained specialist.

The *Batavia* hair samples are composed mainly of tufts of fur and diagnostic guard hairs, indicating that these hairs derive from the same type of animal (see fig. 4-45).⁴⁷ This also indicates that the goat hair was used in its entirety, including the underwool. In general, the preserved goat hair found on the *Batavia* ship’s timbers seems to have come from black or dark brown goats.

In addition to goat hair, a mosslike material was found between the ends of a vertical flat scarf of hull plank BAT 6404, the aftermost end of strake 13 (approximately 80 cm forward of the transom). Most of the original overlying exterior end of this scarf had disintegrated on the seabed, exposing on the exterior face of the inner scarf what could have been moss as luting or coating in between the two scarf ends. The material was not sampled before conservation for species identification. Unfortunately, it was not preserved during the timber’s conservation treatment so is no longer available for further investigation and analyses (see figs. 4-17 and 4-46).

Although several ships from the medieval period have been found with waterproof-

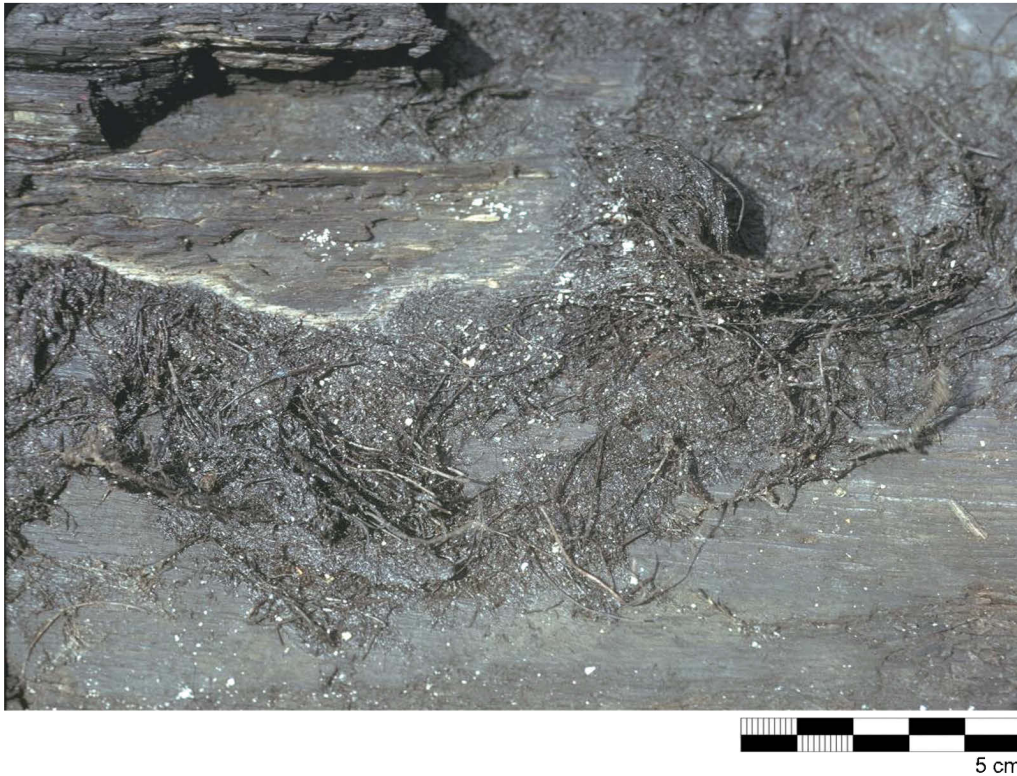


FIGURE 4-46.
Moss layer on exterior
surface of inner layer
of a vertical scarf, BAT
6404. Photograph by
Patrick Baker, Western
Australian Museum
(BT-67-09).

ing of goat hair, *Batavia* is the first-known archaeological example of a postmedieval ship with layers of goat hair. The ship of Newport, for example, built pre-1445, is waterproofed with tar and a mixture of animal hair, including goat and cattle hair, horsehair, and sheep's wool.⁴⁸

Michael Ryder published an extensive study in 1998 on 200 samples of animal hair from caulking on medieval ship timbers found in England, most of which were reused as quay revetments. Ryder's study indicates that cattle hair was the most common hair used for caulking in the twelfth century, while goat hair predominates in the fourteenth and fifteenth centuries. The most common fibrous material used for caulking in the sixteenth century is wool. Ryder's work contrasts a similar study on caulking material from Norway that shows a steady change from wool in the twelfth century to cattle and goat hair in the fifteenth century.⁴⁹

Another study on ship's caulking material by Cappers et al. indicates the predominant use of mosses to caulk Dutch ships dating to the later Middle Ages. Their study was based on 182 caulking samples from 98 shipwrecks. Some samples from shipwrecks dating to the medieval and postmedieval periods consisted of only hair or a mixture of hair and moss. Other than the observation that this hair is of considerable length so probably originates from horses and cattle, no efforts were made to identify the hair.⁵⁰

The application of goat hair in *Batavia* is noteworthy, as cattle hair has been found between the hull planking of other European shipwrecks such as *Monte Cristi* (1650s), possibly *Zeewijk* (1727), and *Nieuwe Rhoon* (1776).⁵¹ Layers of animal hair may have been observed in many wrecks of VOC ships, but no scientific study has been conducted on this material to identify it. In most cases, cattle hair seems to be the material assumed,

based on historical research, as seen in the early publications on the *Batavia* ship itself and, more recently, VOC ships *Mauritius* (1609), *Kampen* (1627), and *Buitenzorg* (1760).⁵² This assumption probably follows Witsen and Van IJk, who both explicitly mention the use of cattle hair.⁵³ The earliest VOC shipbuilding charter of 1603 simply refers to hair. Nonetheless, cattle and goats had been the largest populations in Dutch animal husbandry since the early medieval period, demonstrated, for example, by the leather used to manufacture shoes from the eleventh century onward. Leather shoe remnants found in archaeological contexts in the Netherlands are made primarily from cattle or goat hides.⁵⁴

Although the VOC purchased goat hair or wool for high-quality fabrics, such as mohair, in Kirman from 1658 or in Gamron (modern-day Bandar Abbas, Iran), goat hair for caulking its ships was almost certainly acquired locally.⁵⁵ It is known that the VOC purchased substantial quantities of cattle hair in the eighteenth century. For the Chamber of Amsterdam, this consignment was acquired annually in bulk, usually during butchering season. Some 22,248 pounds of cattle hair were purchased for 440 guilders in October 1742, and 16,158 pounds for 343 guilders in October 1748. Both batches of hair were purchased from the sole supplier in that period, Geert Oetses.⁵⁶ It is unknown whether similar procedures applied to the seventeenth century.

Layers of animal hair were also applied to the Christianshavn B&W 2 (1620s) and VOC ship *Amsterdam* (1748), but no analytical study has been made to identify the animal species.⁵⁷ Although layers of animal hair between the hull planking and pine sheathing have been found on the hull timbers of many VOC and contemporaneous shipwrecks, few studies on the nature of the fibrous matter have been made to date.

RESINOUS AND SULFUR PAYING MATERIALS

The goat hair was probably payed onto *Batavia*'s hull with a mixture of sulfur and tar, or pitch.⁵⁸ Although a preliminary study of one hair sample from *Batavia* has confirmed the presence of pine tar components, no comprehensive study to distinguish between tar and pitch has been conducted to date.⁵⁹ Generally, little study has been undertaken to identify the various coating materials used on seventeenth-century VOC ships. Animal hair examined from the Monte Cristi shipwreck was reportedly mixed in with tar, resin, or pitch.⁶⁰ Furthermore, the coating of the Christianshavn B&W 2 is said to be a mixture of hair, tar, and finely ground glass.⁶¹ However, no specific analysis seems to have been conducted on the tar found in the hair samples of either of these shipwrecks.

To the author's knowledge, Godfrey and Ghisalberti have performed the only study of resinous paying materials from a VOC ship. They studied such coatings from several shipwrecks, including samples from the *Vergulde Draak* wreckage. Like *Batavia*'s, the resinous substance from *Vergulde Draak* was found to be sourced entirely from retorted pine resin, but no further distinction was made between pitch and tar.⁶²

The picture is muddled further regarding investigation of sulfur as a hull coating additive. Determination of whether VOC shipbuilders added sulfur to the hair and resinous material mixture is complicated by the high sulfur content of iron corrosion products from the ship's fastenings. These products are likely to have diffused into the hair mixture between the planks as they corroded underwater. Sulfur analysis is difficult because it is not possible to use stable isotope measurements on elemental sulfur, since the source of the mineral would be inorganic regardless of whether it came from natural seeps or from the chemical oxidation of sulfide ions produced by anaerobic microbial activity. However,

comparison of the ratio of organic to inorganic sulfur in the various samples may provide a good indication—if this ratio is constant—that the sulfur was added deliberately to the tar when the ship was payed.⁶³

CAULKING MATERIAL

No strands of animal hair or other caulking material have been found in the plank-ing seams of *Batavia*. The seams were apparently fitted so tightly that no additional caulking was needed. This is similar to the Dutch-built Indiaman found at Christianshavn.⁶⁴ *Batavia*'s only caulking was composed of goat hair inserted to fill up the cavities between poorly fitting joints, such as the scarf tips of the outer layer of hull planking of strakes 9 and 11 (see fig. 4-13). Here, wads of hair were simply stuck into the significant gaps between the scarf tips. It is unknown whether these wads of hair were payed with tar or pitch.

FRAMES

Forty-six remnants of *Batavia*'s framing have been preserved (C1–C46), mainly comprising first, second, and third futtocks (figs. 4-47 through 4-49). The only possible remnant of a floor timber is a small timber fragment, BAT 6289, found at C37 over hull planking strake 4. Looking at *Batavia*'s frames makes evident that the efforts of the ship-builders were not focused on its frames, as their arrangement and shape have a haphazard and rough appearance in comparison to that of the hull planking (see fig. 3-29). They obviously were a secondary focus, not primary in the design philosophy of the shipwrights.

All frame remnants excavated in the first season, C1–C10, in the foremost section of the preserved hull, have worm-eaten and eroded surfaces. Most frames in this section were sitting on the seabed, fractured along their lengths into smaller adjoining fragments.

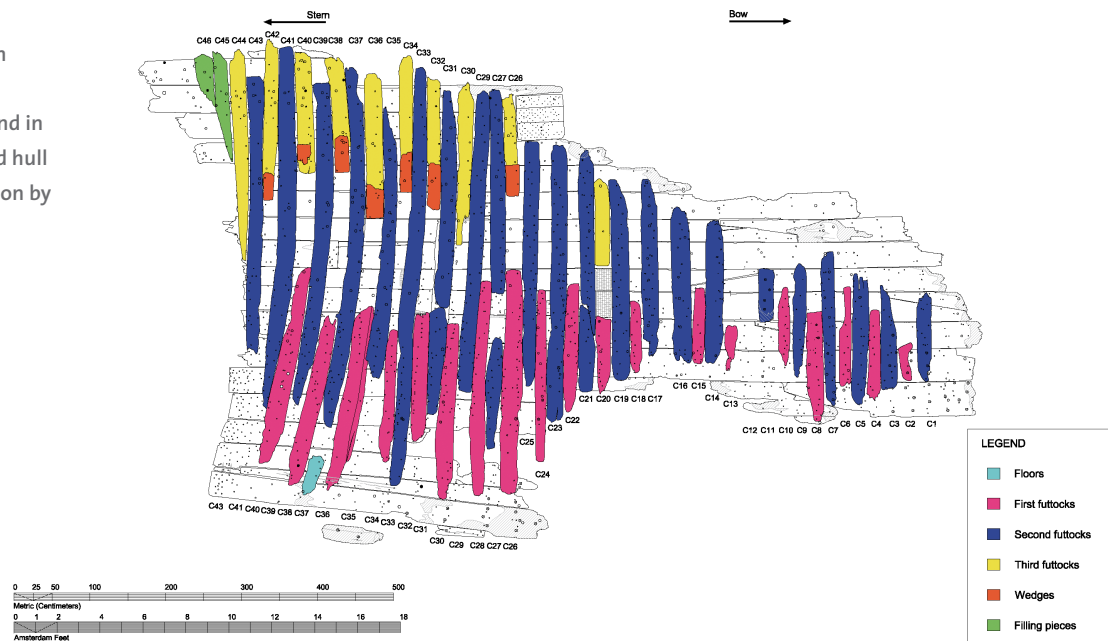


FIGURE 4-47.
Timber plan of *Batavia*'s
frame. Illustration by
author.

FIGURE 4-48.
Reconstruction plan of
Batavia's frame timbers.
Illustration by author.



FIGURE 4-49.
Reconstructed plan
showing types of
frame timbers found in
Batavia's preserved hull
structure. Illustration by
author.



Field numbers C1–C46 were given only to frame remnants that were physically present on the seabed. Originally a first futtock was situated between C16 and C17, for example, but no field number was given as no actual remains were found in situ. Then, two frame fragments, C11 and C12, were mistaken on the seabed for two different frames. They turned out to be fragments of the same second futtock.

Batavia's first and third futtocks have been only partially preserved at the bottom and top of the ship's hull structure, whereas the large sections of the second futtocks have



FIGURE 4-50.
Various sizes of wedges
from the lower ends
of the third futtocks,
BAT 6310, BAT 6307, and
BAT 6305. Photograph
by Patrick Baker,
Western Australian
Museum (MA0422-04,
MA0422-05,
MA0423-09, and
MA0423-10).

been preserved over the entire preserved hull section. The first and second futtocks and second and third futtocks are not interconnected or transversally fastened but overlap each other at their ends to form an irregular band of timber. The frame timbers are preserved over lengths varying from 51.3 cm to 3.97 m, with an average length of 1.76 m. Their average sided dimension is 20.7 cm and average molded dimension is 19.1 cm. The room and space between the second futtocks varies from 35.3 to 48.2 cm, with an average of 41.4 cm (see fig. 4-49).

As mentioned previously, no signs of lateral fastening have been observed between the overlapping futtocks of each frame timber.⁶⁵ The frames were fastened to the ship's bottom planking with treenails, and the planking was nailed to the frames of the ship's sides and the aftermost ends of the bottom planks. Only the lower futtocks, up to at least hull planking strake 11 in the transverse direction and from C1 to C34 in the longitudinal direction, have treenails preserved. All frame timbers above strake 14 and from C35 to C46 show that the planking was fastened exclusively with iron spikes.

Wedges were nailed over the lower ends of the third futtocks to fill the space between the beveled frame ends and the ceiling planks above the shelf clamp (see fig. 4-49). Seven of these preserved wedges are triangular in cross section and vary from 18.4 to 61.6 cm in length and from 14.5 to 26.4 cm in width (fig. 4-50). Their maximum thickness is between 9 and 17.5 cm on their lower ends, from which they taper to a point at their top ends where they sit over their respective frames.

CEILING PLANKING AND SHELF CLAMP

Twelve strakes of ceiling planking and a shelf clamp were found atop the frames and fastened to the frames with iron nails (fig. 4-51). The ceiling planking is well preserved in the aftermost section of the hull, which was excavated in the last season, whereas its state of preservation directly forward of this section, below the gun port, is fragmentary. Here, the planks have nearly completely decayed.

The lowest six strakes of preserved ceiling planking vary in thickness from 6 to 7.1 cm, with an average of 6.4 cm. The strakes above strake 7 show a definite increase in thickness. Strakes 7 and 9–13 vary in thickness from 8 to 9 cm, with an average of 8.7 cm, which is

The eighth strake comprises the shelf clamp of *Batavia*'s lower deck or platform in the stern. It is much thicker than the ceiling planking and has two preserved notches to seat the deck beams (see fig. 4-51). The shelf clamp has been preserved over a total length of 3.9 m, although it was cut into two sections during excavation (BAT 6322 and BAT 6185). It measures 42.8 cm in width and 12 cm in thickness. In addition, the ninth ceiling strake has one notch on its bottom face to sit over the forwardmost surviving deck beam notch.

Originally, a pine cargo floor covered the ceiling planking up to the lower deck (fig. 4-52). Three fragmentary planks of this cargo floor have been well preserved on strakes 1-3. These planks measure from 1.71 to 1.90 m in length, and from 35.2 to 56 cm in width. Their maximum thickness varies from 2.6 to 3.6 cm. Two more fragmentary planks were found on the forward end of the shelf clamp (BAT 6089) and below ceiling planking strake 7 (BAT 6232). This pine floor was supported by small vertical laths nailed onto the ceiling planking that were found underneath the preserved floorboards (figs. 4-53 and 4-54). Most laths are about 6.3 cm wide, but one measures 7.7 cm. Their preserved lengths vary from 21.7 to 45.1 cm, and their thicknesses are only a few centimeters due to their poor state of preservation. Their room and space on plank BAT 6273 varies from 37.4 to 46.5 cm, and on strakes 5 and 6 it measures 57.7 cm.

FIGURE 4-54. Internal (*top*) and outboard (*bottom*) surfaces of pine plank BAT 6273 from cargo floor. Note vestiges of laths on outboard surface. Photographs by Catherina Ingelman-Sundberg, Western Australian Museum (MA0399-11 and MA0399-12).



of the Western Australian Museum using a Bruker AXS Handheld XRF apparatus. The chemical analysis was conducted on seven different spots on the planking's surface. The results mainly show high concentrations of iron and corrosion in the form of iron corrosion products and insignificant amounts of lead (fig. 4-55). If the cargo floor had been covered with lead sheathing, the amount of lead and lead corrosion products preserved on its surface would have been much higher due to the anaerobic conditions prevalent under the dense concretion. It is therefore more likely that the surface layer is a combination of anaerobic concretion and iron corrosion products formed from the corroding cannonballs.

A pine subfloor was found above the lower deck in alignment with the gun port beneath ceiling strakes 11 and 12 (which correspond to hull planking strakes 18 and 19). A plank of this subfloor found beneath strake 12 measures 2.15 m in length, 47.1 cm in width, and 3.5 cm in thickness (BAT 6260). Another one situated beneath strake 11 is somewhat smaller and measures 1.58 m in length, 18.3 cm in width, and 5 cm in thickness (BAT 6276). The precise function of this subfloor is unknown, but it may relate to the reinforcement of the gun ports (see fig. 4-52).

Other contemporaneous Dutch-built ships, such as the Scheurrak SO1 and Christianshavn B&W 2, have ceiling planking that is treenailed through frames into the inner layer of oak hull planking. No evidence of treenail fastening of the ceiling planking strakes on *Batavia* exist. As previously discussed, the aftermost hull planking of the ship's bottom was nailed, not treenailed, to the fashion piece and frames. The ceiling planking has been preserved mainly in this particular area, and it could simply have been fastened according to the fastening method used for the planking.

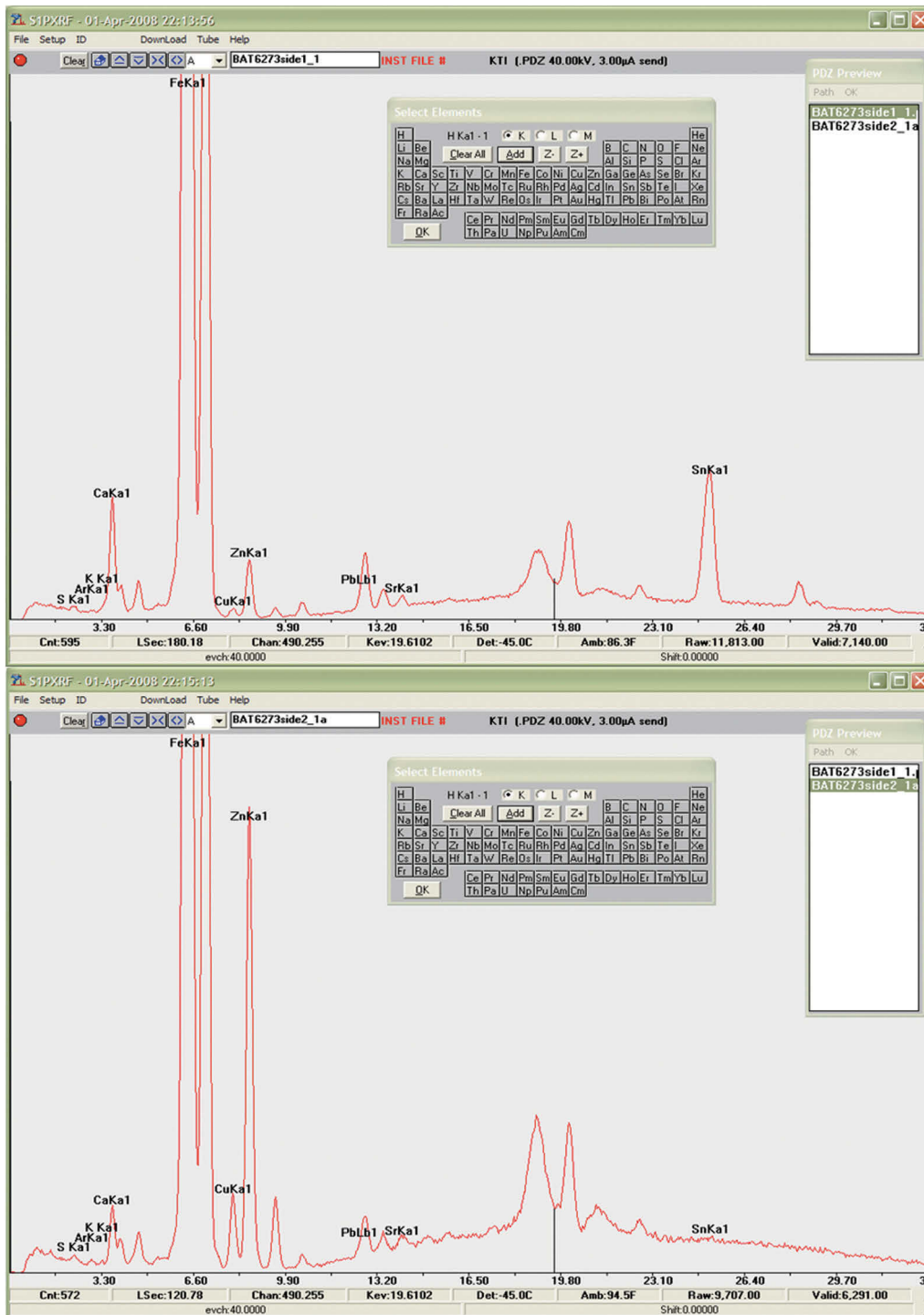


FIGURE 4-55. Screenshot of results of two XRF spot tests on pine floor plank BAT 6273. Illustrations by Bruce Kaiser.

RIDERS

No riders, or rider frames, survived the *Batavia* shipwreck, but their original presence is confirmed by their fastening holes in the preserved hull remains. Round bolt holes mark where riders and hanging deck knees were fastened to the hull and are primarily found from frame C31 forward toward the bow (at frames C30, C27, C24/C23/C22, C17, C16, C14, C11, C7, and at the foremost edge of the preserved hull). The riders had an irregular room and space that, in the surviving hull section at least, varied from 46 cm to 1.73 m. The use of riders is confirmed as well in the construction of the Christianshavn B&W 2 ship.⁶⁷

STERNPOST

As displayed in the museum, the after face of *Batavia*'s sternpost has an inclination of 107.5 degrees to the keel and an angle of approximately 114 degrees to the keel where it meets the transom planking. The sternpost was originally covered on each out-board side with several layers of material for additional reinforcement and protection (fig. 4-56). The innermost layer, nailed to the sternpost, was oak planking on top of which thin sheets of copper sheathing were added. A layer of pine sheathing was then fastened over the copper sheathing.⁶⁸ A thin layer of goat hair and a resinous substance was applied to the inner and outer surfaces of the pine sheathing.

FIGURE 4-56.
After face of sternpost
with layer of oak cover
planking and pine
sheathing on starboard
and port sides.
Photograph by author.



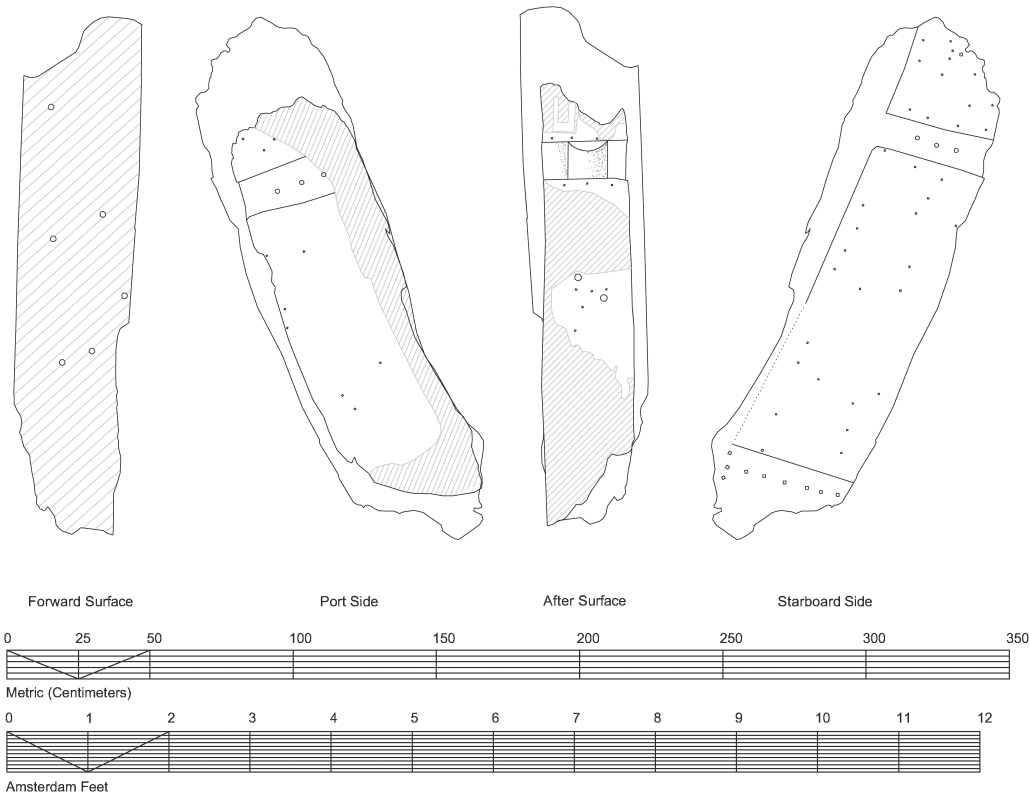


FIGURE 4-57.
Sternpost, BAT 6434.
Illustration by author.

The preserved section of sternpost measures 1.54 m in length over its aftermost face and 1.82 m over its foremost face (fig. 4-57). It measures 52.8 cm in molded dimension and tapers in sided dimension from 41.9 cm forward to 32.9 cm aft. An impression of the sternpost rabbet, preserved on its port side only, shows that the rabbet line was curved. As discussed previously, the transom planking had a curvature to it, which is clearly shown by the rabbet line. In addition, the sternpost was notched on its after face and on either side of the post to receive the rudder gudgeons (see fig. 4-56).

The concretions of two iron rudder gudgeons were found, but one, upper gudgeon BAT 80104, is still in wet storage and not available for study. Interestingly, the preserved transom planking indicates that the ends of this gudgeon flared on each side of the transom planking, where they were fastened between the two layers of transom planking on each side of the sternpost (see figs. 4-34 and 4-37). This practice provided strong lateral support for the gudgeons and its fasteners. The gudgeon arms were secured to the inner layer of transom planking by two iron spikes. The upper gudgeon was secured to the sternpost with large iron bolts, whereas the lower preserved gudgeon was fastened with smaller bolts or large iron spikes. The heads of the bolts from the upper gudgeon have left perfectly rounded circular impressions on the interior surface of the upper cover planking (measuring 4.5 cm in diameter; figs. 4-58 and 4-59).

The second rudder gudgeon, BAT 80395, is the lower one from the preserved sternpost. This concretion has been cast for replication purposes and museum display (fig. 4-60; note that the upper gudgeon in fig. 4-56 is a replica of the lower gudgeon). The gudgeon was fastened to the sternpost with seven iron bolts or large spikes per side. The preserved

FIGURE 4-58.
Cover planking on
port side of sternpost,
BAT 6433 C–BAT 6439.
Illustration by author.

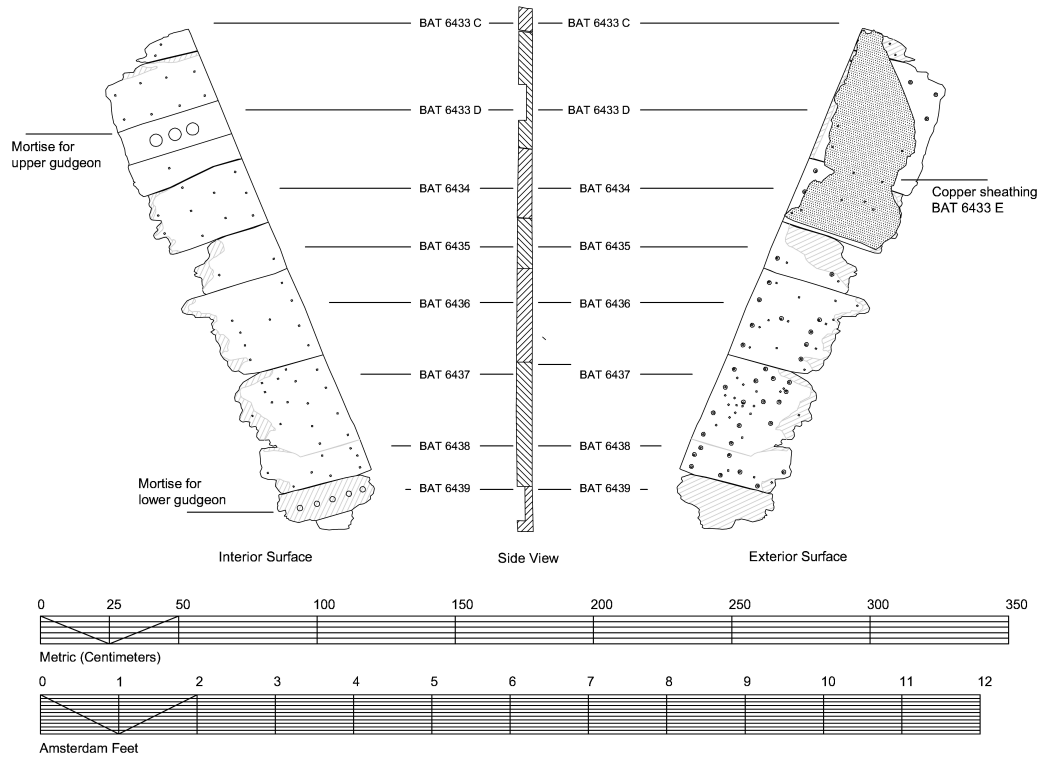


FIGURE 4-59.
Cover planking on
starboard side of
sternpost, BAT 6246–
BAT 6251. Illustration by
author.

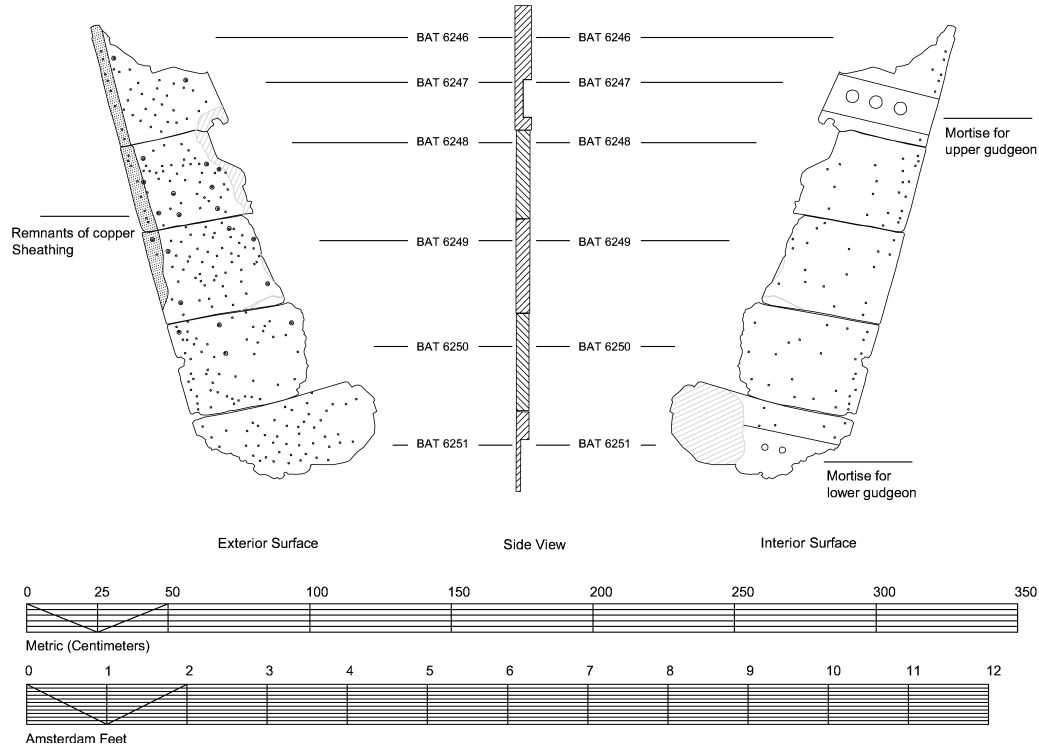




FIGURE 4-60. Casting of lower preserved gudgeon from iron concretion, BAT 80395 R. Photograph by Jon Carpenter, Western Australian Museum.

gudgeon measures 36 cm in length and tapers in width from 15.5 cm at its aftermost end to 11.4 cm where it runs in between the sternpost and the cover planking. It measures 3.8 cm in thickness, although it is slightly thicker, 5.5 cm, at its aftermost end where it seated the pintle. The hole for the pintle measures 8.5 cm in diameter.

Seven fragmentary covering planks have been preserved from the sternpost's outboard port side and five on its starboard side (figs. 4-61 and 4-62). They vary in maximum length from 32.2 to 64.3 cm and in maximum width from 18.3 to 47.7 cm. The thicknesses of the planks measure from 4.5 to 5.8 cm, with an average of 5.3 cm.

The inner layer of oak cover planking on the sternpost has shallow mortises cut out to receive the ship's gudgeons. The smaller fasteners of the lower gudgeon have left a rounded impression with an average diameter of 2.2 cm. The lower gudgeon mortises have not preserved well, although the starboard mortise measured 12 cm in width and the port mortise, 11.4 cm. The upper mortise is 14 cm wide on both starboard and port sides. The notches are 2.9 cm deep.

Six planks of pine sheathing have been preserved that were nailed onto the cover planking on the starboard side and two on the port side (see figs. 4-61 and 4-62). They vary in maximum length from 19.3 to 56.6 cm and in maximum width from 15.9 to 61.9 cm. The thicknesses of the planks measure from 2.7 to 3.5 cm, with an average of 2.9 cm. Of the two layers of planking that protect the sides of the sternpost, the cover planking is slightly thicker than the sheathing.

The pine sheathing planking on the starboard side of the sternpost shows Roman numerals representing draft marks numbered from XVI to XX (see fig. 4-62).⁶⁹ On the port side, numbers XVIII to XXI have only partially survived (see fig. 4-61). The Roman numeral I is indicated by a single round dot, as are half values. The letters are a maximum

FIGURE 4-61.
Pine sheathing planks,
port side of sternpost,
BAT 6433 A and BAT
6433 B. Illustration by
author.

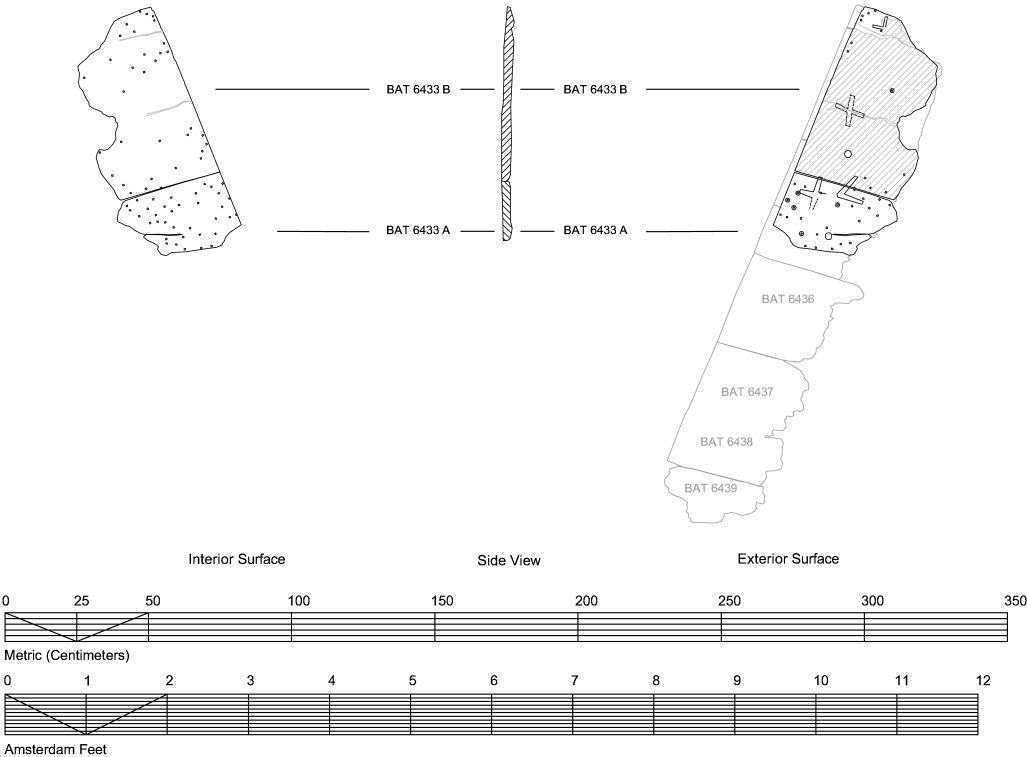
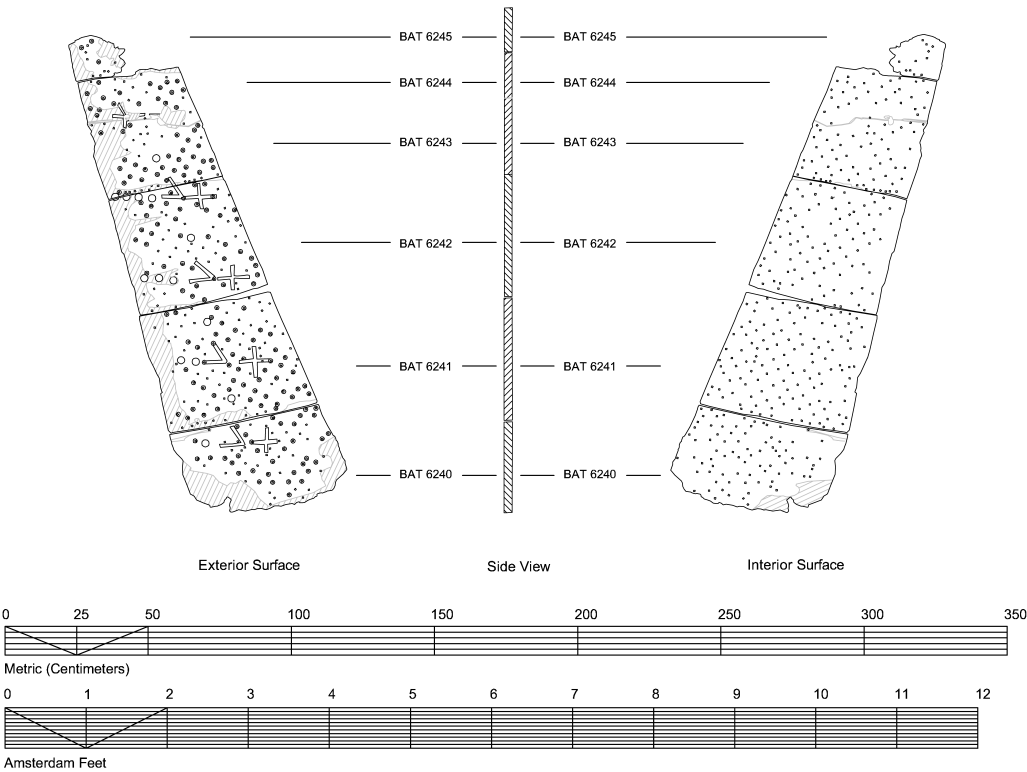


FIGURE 4-62.
Pine sheathing planks,
starboard side of
sternpost, BAT 6240–
BAT 6245. Illustration by
author.



of 12 cm tall. On the starboard side, these marks read from right to left, whereas on the port side they read from left to right. Roman numeral XIX is represented as XVIIII. The numbers are carved into the wood parallel to each other at distances varying from 28 to 30.3 cm, with an average of 29.4 cm. They are, therefore, not perfectly in concordance with the Amsterdam foot of 28.31 cm. Witsen mentions in his manuscript that numbers were applied on the sternpost so a ship's draft could be read.⁷⁰

The pine sheathing planks were fastened to the inner cover planking with iron nails closely set in a quincunx pattern. These nails had the same dimensions and spacing as those of the pine sheathing nailed to the hull planking. A layer of a resinous substance and goat hair was applied to the exterior and interior surfaces of the pine sheathing, in addition to a layer of copper sheathing in between the cover planking and pine sheathing.

From the waterline markings on *Batavia*'s sternpost sheathing, it is possible to determine the position of the bottom of the keel. From these calculations, it is known that 4.1 m is missing from the sternpost below its preserved section (including the thickness of the keel).

COPPER SHEATHING

Batavia's sternpost was partially sheathed with thin copper sheets fastened with copper tacks to the oak cover layer. Only small parts of the copper sheathing survived together with the sternpost. The copper sheathing was, however, not recorded in detail underwater or directly after excavation. From observations made in the field and from recent study, it is known that the copper sheets were nailed over the inner layer of oak cover planking—underneath the pine sheathing—and copper strips were nailed over the hood ends of this cover planking. Tool marks indicate that these strips of copper were hammered around the corners of the post's sides and aftermost face. It is possible that the entire aftermost surface of the sternpost was sheathed with copper, but no evidence has been found to support this. One large fragment of copper sheet was found between the oak cover planking and pine sheathing of the port-side sternpost (see fig. 4-58, BAT 6433 E). Other bits of copper sheets raised from the seabed represent fragments of the strips that were folded over the cover planking's sides and after hood ends (see figs. 4-59, 4-63, and 4-64).

The fragments of copper sheathing are poorly preserved and have an average thickness of 3 mm. Their preserved length varies from 13.4 to 74.6 cm, and their width from 6 to 42.3 cm. Some still retain copper sheathing tacks, and others, only their holes. The tack holes are square and average 6 mm in section.

The preserved copper tacks have irregular flat heads, indicating that the soft metal was flattened and deformed when driven into the wood (fig. 4-65). Their shanks are square in section (6 mm) from below their heads to the tips and taper in thickness to about 2 mm. Their tips are pointed. The copper tacks have an average length of 3.1 cm. Their heads vary in diameter from 1.1 to 2.3 cm, and their head thickness generally tapers from 3 mm in the centers to 1 mm at the edges.

A semiquantitative chemical analysis of the material was conducted on six fragments of copper sheathing and four tacks to approximate their composition (table 4-2). The copper purity in the fragments and tacks varies between 96.16% and 99.49%. The concentrations of natural trace elements found in the copper, such as arsenic, iron, lead, nickel, and zinc, were generally found to be less than 1%.



FIGURE 4-63. Fragments of copper sheathing and tacks from sternpost. Photograph by Patrick Baker, Western Australian Museum.

FIGURE 4-64.
Fragments of copper sheathing protruding along the edge (arrows) from beneath the starboard pine sheathing of the sternpost. Photograph by ABC Peach's Australia, *The Unlucky Voyage*, 1990, Western Australian Museum.



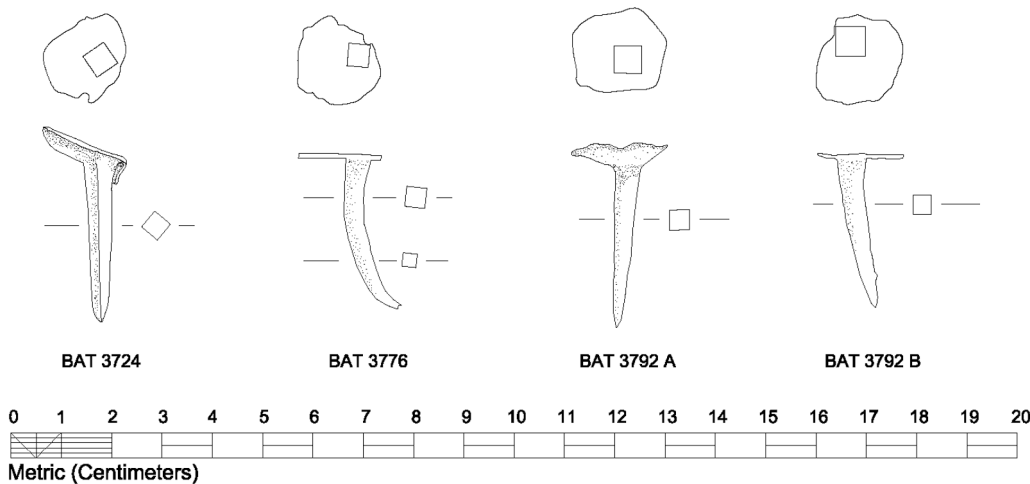


FIGURE 4-65.
Copper tacks for
fastening copper
sheets to the sternpost.
Illustration by author.

From 1613, the Dutch had gained control over the transport of Swedish copper. The raw material was shipped in large annual shipments from Sweden to Amsterdam, which had become Europe's staple market for Swedish copper.⁷¹ Historic studies indicate that Sweden was, in fact, the principal supplier of copper used by the Dutch in general and the VOC in particular.⁷² Therefore, samples from five fragments of copper sheets and six copper tacks were sent to the Laboratory for Isotope Geology, Swedish Museum of Natural History, for lead isotope analyses.⁷³ The samples were analyzed in four individual sessions by an Isoprobe ICP-MS, after which all data were normalized to the standard reference value for NBS981.⁷⁴ Comparison of the *Batavia* data with the ores of Swedish mining areas reveals that only two samples of sheathing, BAT 3827 and BAT 3438, yield a typical Swedish Bergslagen lead isotope signature. The lead isotope signatures of eight *Batavia* samples form a cluster in figure 4-66, which is distinctly different from the lead isotope ratios that characterize the mines in central Sweden. The lead of these samples is isotopically "more evolved," as it has higher $^{206}\text{Pb}/^{204}\text{Pb}$, $^{207}\text{Pb}/^{204}\text{Pb}$, and $^{208}\text{Pb}/^{204}\text{Pb}$ ratios than lead from Bergslagen (table 4-3).

The latter, which displays a very homogeneous isotopic composition, was formed in the early Proterozoic, around 1,890 million years ago.⁷⁵ Ores utilized for most of *Batavia*'s copper fasteners must have formed in a much more recent time, given their evolved isotopic signatures, and their formation during the Phanerozoic, roughly from present to 545 million years ago, is suggested. Many worldwide ore beds are characterized by Phanerozoic ores, including areas in eastern Asia and around the Mediterranean Sea. The isotopic signatures of the evolved *Batavia* samples straddle those of Japanese ore fields, and to a lesser extent Iberian ore leads.⁷⁶ Both regions have been well known for their copper-mining industries since antiquity.⁷⁷ The VOC gained a monopoly over trade with Japan in 1640 and started shipping Japanese copper in 1646, mainly for the Southeast Asian market.⁷⁸ However, beginning in the 1620s, cargoes including Japanese copper were frequently mentioned in the daily journal kept in Batavia castle.⁷⁹

One intermediate signature occurred (BAT 3149) that could hypothetically constitute a mixture of two lead components, involving, for example, a Japanese and a Bergslagen ore, or that may come from a third, unidentified mining area.⁸⁰ As the lead isotope composition of the BAT 3149 sample plots on binary mixing trends (end compositions defined by

TABLE 4-2. Results of EDAX analysis of *Batavia* sternpost sheathing and tacks

Sample	Source	Wt (%)									At (%)								
		SiK	SbL	SnL	FeK	NiK	CuK	AsK	PbL	Total	SiK	SbL	SnL	FeK	NiK	CuK	AsK	PbL	Total
BAT 0582	Sheathing	0.82	0.31	0.14	0.24	0.19	97.35	0.00	0.94	100	1.86	0.16	0.08	0.28	0.20	97.13	0.00	0.29	100
BAT 0582	Sheathing	0.71	0.00	0.00	0.19	0.16	98.28	0.00	0.66	100	1.61	0.00	0.00	0.21	0.17	97.81	0.00	0.20	100
BAT 0582	Sheathing	0.52	0.12	0.10	0.28	0.07	98.40	0.00	0.51	100	1.17	0.06	0.05	0.31	0.08	98.17	0.00	0.16	100
BAT 0582	Sheathing	0.46	0.12	0.09	0.15	0.06	98.58	0.00	0.54	100	1.04	0.06	0.05	0.18	0.07	98.44	0.00	0.16	100
BAT 3149	Sheathing	0.09	0.00	0.00	0.06	0.40	99.33	0.00	0.12	100	0.19	0.00	0.00	0.07	0.43	99.27	0.00	0.04	100
BAT 3149	Sheathing	0.08	0.00	0.00	0.08	0.42	99.33	0.09	0.00	100	0.19	0.00	0.00	0.09	0.45	99.20	0.07	0.00	100
BAT 3149	Sheathing	0.08	0.00	0.00	0.08	0.32	99.47	0.05	0.00	100	0.17	0.00	0.00	0.09	0.34	99.36	0.04	0.00	100
BAT 3438	Sheathing	0.26	0.00	0.00	0.12	0.14	97.45	0.13	1.90	100	0.59	0.00	0.00	0.13	0.15	98.43	0.11	0.58	100
BAT 3438	Sheathing	0.15	0.00	0.00	0.10	0.10	96.16	0.38	3.11	100	0.34	0.00	0.00	0.11	0.11	98.12	0.33	0.97	100
BAT 3649	Sheathing	0.06	0.00	0.00	0.11	0.22	99.49	0.00	0.12	100	0.13	0.00	0.00	0.13	0.24	99.46	0.00	0.04	100
BAT 3724	Tack	0.10	0.11	0.00	0.10	0.35	99.25	0.09	0.00	100	0.22	0.06	0.00	0.12	0.38	99.14	0.08	0.00	100
BAT 3724	Tack	0.04	0.02	0.00	0.08	0.40	99.37	0.00	0.09	100	0.09	0.01	0.00	0.09	0.44	99.34	0.00	0.03	100
BAT 3724	Tack	0.32	0.65	0.12	0.12	0.30	98.07	0.00	0.42	100	0.72	0.34	0.06	0.14	0.32	98.29	0.00	0.13	100
BAT 3724	Tack	0.47	0.56	0.16	0.15	0.21	97.78	0.00	0.67	100	1.07	0.29	0.09	0.17	0.23	97.94	0.00	0.21	100
BAT 3754	Sheathing	0.20	0.30	0.00	1.17	0.34	96.66	0.00	1.32	100	0.46	0.16	0.00	1.34	0.38	97.25	0.00	0.41	100
BAT 3754	Sheathing	0.04	0.07	0.03	0.58	0.26	98.26	0.00	0.76	100	0.09	0.04	0.02	0.67	0.28	98.66	0.00	0.23	100
BAT 3754	Sheathing	0.23	0.25	0.08	1.18	0.16	96.91	0.00	1.18	100	0.53	0.13	0.04	1.36	0.17	97.40	0.00	0.37	100
BAT 3776	Tack	0.53	0.47	0.08	0.13	0.26	98.14	0.00	0.39	100	1.20	0.24	0.04	0.15	0.28	97.97	0.00	0.12	100
BAT 3776	Tack	0.48	0.44	0.12	0.12	0.17	98.26	0.00	0.41	100	1.09	0.23	0.06	0.14	0.19	98.17	0.00	0.12	100
BAT 3792 A	Tack	0.40	0.67	0.13	0.14	0.22	97.66	0.06	0.72	100	0.90	0.35	0.07	0.16	0.24	98.01	0.05	0.22	100
BAT 3792 A	Tack	0.39	0.25	0.12	0.08	0.13	98.65	0.00	0.38	100	0.88	0.13	0.07	0.09	0.14	98.57	0.00	0.12	100
BAT 3792 A	Tack	0.27	0.82	0.15	0.10	0.17	96.79	0.06	1.63	100	0.62	0.43	0.08	0.12	0.19	97.99	0.05	0.51	100
BAT 3792 B	Tack	0.21	0.40	0.11	0.11	0.26	98.63	0.00	0.28	100	0.48	0.21	0.06	0.13	0.28	98.75	0.00	0.09	100
BAT 3792 B	Tack	0.08	0.17	0.00	0.11	0.31	99.14	0.09	0.10	100	0.18	0.09	0.00	0.12	0.34	99.16	0.08	0.03	100
BAT 3792 B	Tack	0.50	0.49	0.10	0.11	0.14	98.44	0.06	0.16	100	1.13	0.25	0.05	0.12	0.15	98.19	0.05	0.05	100
BAT 3792 B	Tack	0.38	0.33	0.13	0.11	0.21	98.63	0.21	0.00	100	0.86	0.17	0.07	0.13	0.22	98.37	0.18	0.00	100
BAT 3827	Sheathing	0.58	0.22	0.12	0.19	0.33	97.27	0.12	1.17	100	1.31	0.12	0.07	0.22	0.36	97.46	0.10	0.36	100
BAT 3827	Sheathing	0.36	0.12	0.07	0.14	0.35	97.69	0.06	1.21	100	0.82	0.06	0.04	0.16	0.38	98.12	0.05	0.37	100

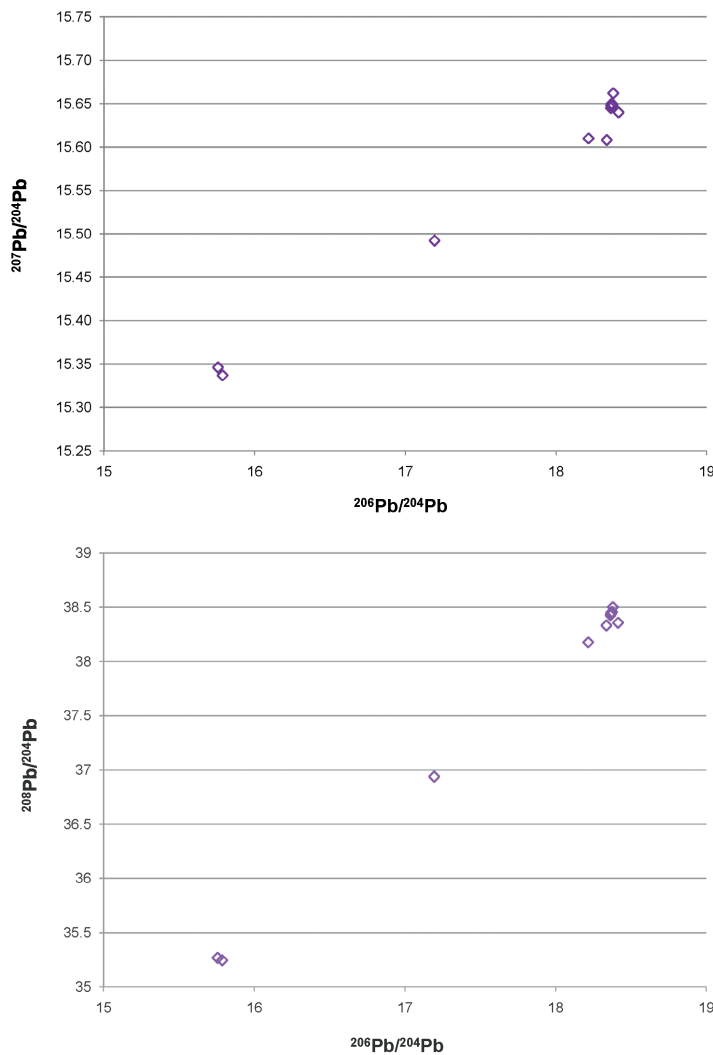


FIGURE 4-66.
Charts plotting lead isotope
values of copper tacks and
sheathing. Illustration by Kjell
Billström.

Bergslagen and Japanese leads) in both the $^{206}\text{Pb}/^{204}\text{Pb}$ versus $^{207}\text{Pb}/^{204}\text{Pb}$ and $^{206}\text{Pb}/^{204}\text{Pb}$ versus $^{208}\text{Pb}/^{204}\text{Pb}$ diagrams, it is suggested that this lead represents a mixture of lead from two ore districts.

No extensive research has been conducted comparing the *Batavia* lead isotope data with those of other mining areas, as the primary objective was to check their consistency with Swedish ores. Although general features of the data and copper mining areas have been compared, some specific source areas cannot be completely ruled out, nor can they be claimed to be 100% consistent with the *Batavia* data.

A noteworthy feature is that the copper tacks define a rather narrow range of lead isotopic compositions, whereas the copper sheets reflect a larger isotopic heterogeneity. Although the analyzed samples are few in number, they suggest that the sheets were prepared independently from the tacks, as different metal sources were involved.

The copper ores used to manufacture *Batavia*'s tacks and sheets appear to originate from at least two different regions; one of these is most likely the Bergslagen ore district in central Sweden.⁸¹ The lead isotope analyses of *Batavia*'s copper sheathing and tacks do demonstrate that it was certainly not the only source, and both Japanese and Iberian

TABLE 4-3. Lead isotope data of copper tacks and sheathing from *Batavia*'s sternpost

Catalog number	Description	$^{206}\text{Pb}/^{204}\text{Pb}$	$^{207}\text{Pb}/^{204}\text{Pb}$	$^{208}\text{Pb}/^{204}\text{Pb}$
BAT 0582	Sheathing	18.216	15.610	38.175
BAT 3149	Sheathing	17.194	15.492	36.937
BAT 3232	Sheathing	18.380	15.662	38.501
BAT 3438	Sheathing	15.787	15.337	35.244
BAT 3484	Tack	18.364	15.645	38.425
BAT 3724	Tack	18.375	15.648	38.455
BAT 3776	Tack	18.367	15.648	38.439
BAT 3792 A	Tack	18.415	15.640	38.357
BAT 3792 B	Tack	18.370	15.650	38.450
BAT 3827	Sheathing	15.757	15.346	35.267
BAT 3831	Tack	18.337	15.608	38.332
Bergslagen	Copper mines	15.700	15.300	35.400

Analyses by Kjell Billström, Laboratory for Isotope Geology, Swedish Museum of Natural History. The analytical uncertainty for all of these results is 0.1% (error 2s).

copper ores should be taken into consideration. The first would, however, be an early occurrence, as a trading relationship between the VOC and Japan was not officially established until 1640. Spain was one of the markets to which the Dutch sold Swedish copper.⁸²

TRANSOM ASSEMBLY

Batavia's port transom timbers and their assembly are similar to those of a galleon.⁸³ The preserved timbers include a fashion piece, an upper fashion piece, the wing transom, and five transom beams (including a deck transom and four transom beams; fig. 4-67). One gun port has been found between the wing transom and the transom beam below it. All measurements listed for the transom timbers are approximate, as they are taken from the field drawings. The actual timbers currently on display are largely inaccessible. The large size also posed a problem during the shipwreck's excavation because they are poorly recorded. Tracings of these timbers are incomplete, and the photography set up on Beacon Island used to record most of the timbers was not suitable for large structural elements.

FASHION PIECE AND UPPER FASHION PIECE

On each side of the stern, the corner of the transom and side of the hull were reinforced by a fashion piece and transom knees, five of which were preserved. The fashion piece BAT 6444 is the single largest timber raised intact from the seabed, measuring about 4.6 m in length, 60 cm sided, and 32 cm molded (figs. 4-67 and 4-68). The after surface of the fashion piece has a maximum preserved sided dimension of 46.9 cm, as it was chamfered to accommodate the angle between *Batavia*'s transom and port side. The fashion piece terminates at the top of the wing transom.

The fashion piece has a flat scarf on top of its after face to receive the wing transom

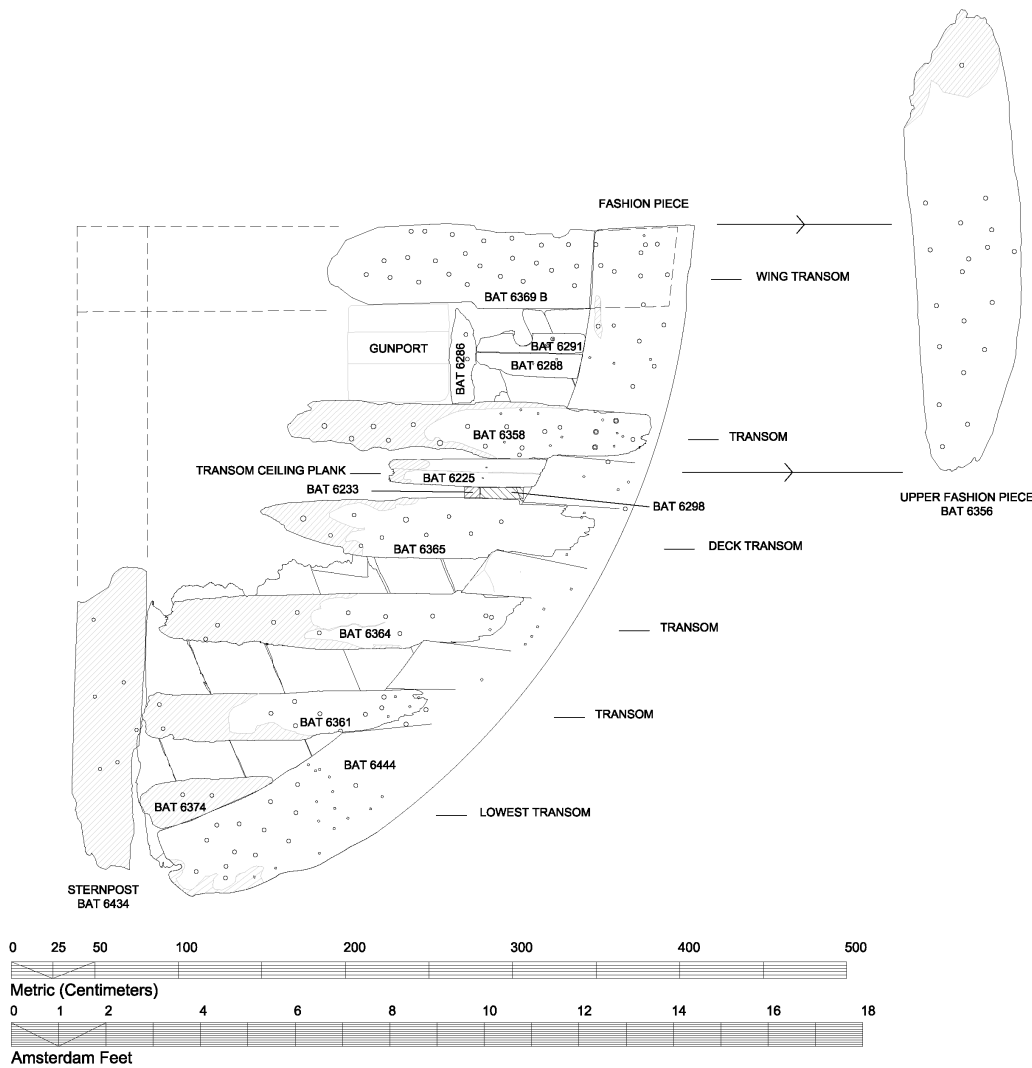


FIGURE 4-67.
Transom timbers,
looking aft. Illustration
by author.

and four large dovetails, spaced at set intervals, along its length on its forward face. These dovetails receive the ends, each vertically flat scarfed, of four transom beams, BAT 6358, BAT 6361, BAT 6364, and BAT 6365 (see fig. 4-67). The flat scarf at the fashion piece's top end is nibbed for 3.6 cm and then measures 49.4 cm in length and spans the entire molded dimension of the fashion piece.

The transom beams were slotted into the dovetail joints on the forward face of the fashion piece; the notches vary between 28 and 38 cm in width, and from 12.9 and 19.4 cm in depth where they receive the transom beams. The dovetails become shallower over the fashion piece's forward face until they disappear toward the exterior edge. The transom beams and wing transom were secured to the fashion piece by iron bolts.

The upper fashion piece was bolted on its top forward end where it sits flush over the highest transom beam, BAT 6358, and was only partially preserved over a length of about 2.8 m (see figs. 4-67 and 4-69). It measures roughly 68 cm sided and 24 cm molded. At least 18 iron bolts fastened it to the fashion piece.

FIGURE 4-68.
Sketch of fashion piece,
BAT 6444. Illustration
by author.

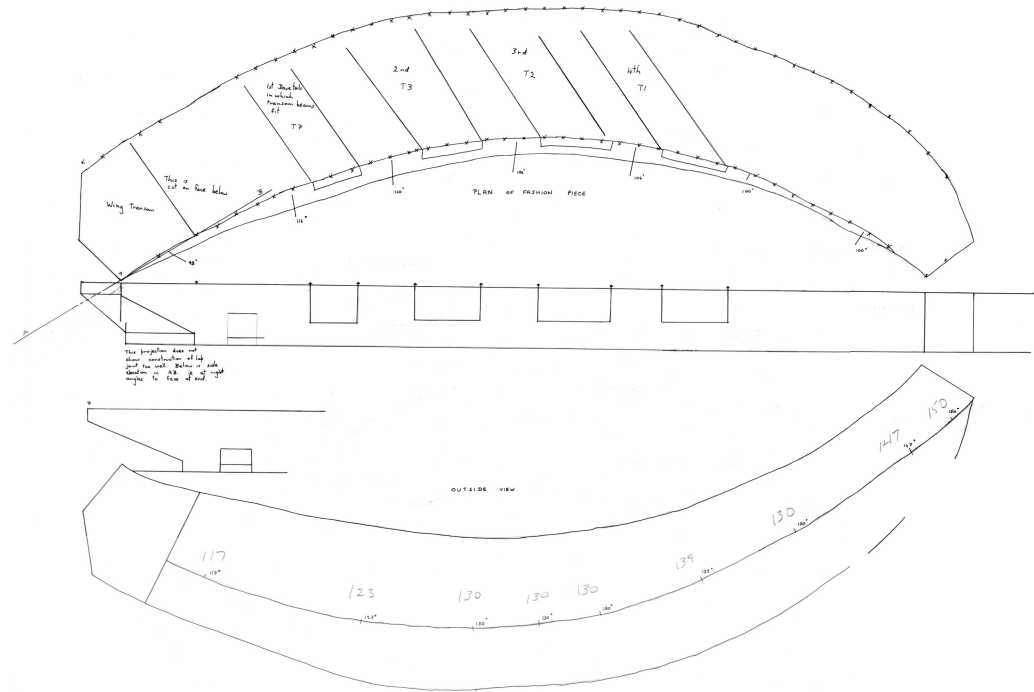
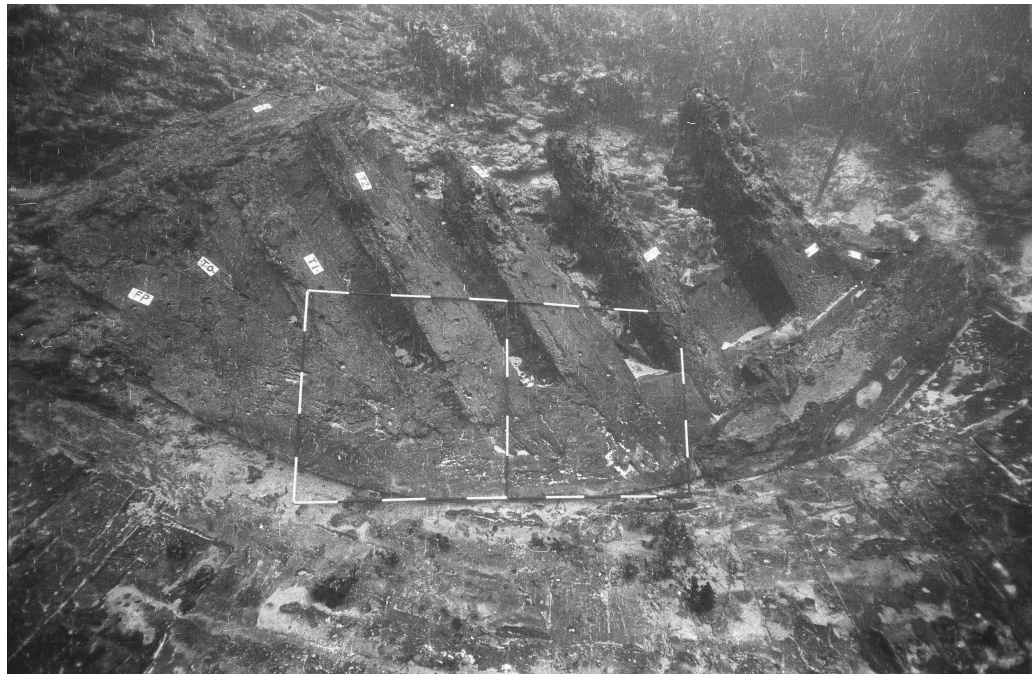


FIGURE 4-69.
Transom timber
assembly in situ.
Photograph by Patrick
Baker, Western
Australian Museum
(MA0410-35).



WING TRANSOM AND GUN PORT

The upper ends of *Batavia*'s diagonal transom planking terminated at a wing transom (figs. 4-67 and 4-70). The partially preserved port side of this piece was found on the seabed with a concreted hinge fitting for a gun port. Wing transom BAT 6369 B is preserved only on the transom's exterior face where it scarfs over the aftermost face of the fashion piece. Its preserved dimensions are approximately 2.1 m in length, 50 cm

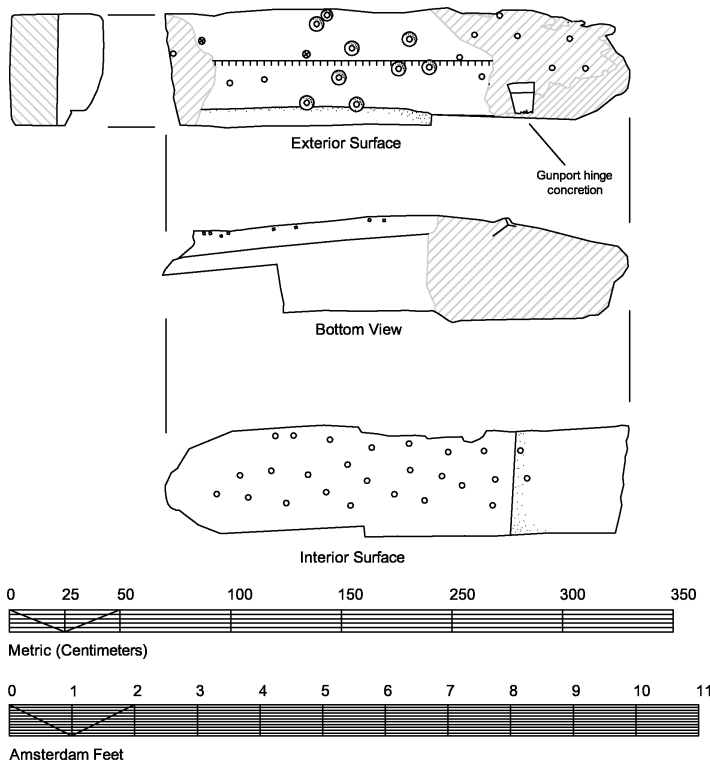


FIGURE 4-70.

Schematic drawing of
wing transom, BAT 6369 B.
Illustration by author.



FIGURE 4-71.

Chamfered after surface
of wing transom with
rabbet to receive transom
planking (timber is lying
upside down), BAT 6369.
Photograph by Patrick Baker,
Western Australian Museum
(MAO414-15).

sided, and 43 cm molded. The scarf end is nibbed 4 cm and measures 5.1 cm in length. At the aftermost lower end a rabbet was cut to receive one layer of transom planking (10 cm in width; fig. 4-71).

The forward face of the wing transom has a flat surface, whereas the aftermost face is chamfered toward the rabbet. The aftermost face of the wing transom and its rabbet are also curved over their lengths to follow the curvature of the transom planking.

The concretion of a gun port hinge and a notch for the port have been preserved, though poorly, on the lower face of the wing transom. The notch measures about 61.5 cm in width; it delineates the width of the transom gun port. The distance between the lower face of the wing transom and the upper face of the transom beam below is 58.6 cm (ex-

actly 2 Amsterdam ft). The transom gun port, therefore, had the same width and height as the gun port preserved on the port side of the hull. The gun port is centered between the transom edge and the port-side edge of the sternpost. On the interior face of the transom assembly, two small horizontal beams have been preserved that reinforce the gun port and the hawse hole next to it (see fig. 4-67, BAT 6288 and BAT 6291). The hinge concretions contain remnants of the iron strap of the hinge mechanism, which is preserved over a length of 15 cm and varied in width from 5.8 to 9.8 cm (BAT 80041, not illustrated). The strap was about 2.6 cm in thickness. The hinge mechanism itself did not survive.

The transom gun port is probably associated with iron cannon BAT 8721, which was found lying on top of it. This cannon is 2.78 m long and had a bore diameter of 12.5 cm. On the starboard side, one additional iron cannon was found, which is probably its starboard-side counterpart, BAT 8720. It measures 2.74 m in length and had a bore diameter of 11 cm, so both cannon generally have the same length and shape.⁸⁴

STANDING KNEE ON EXTERIOR OF UPPER FASHION PIECE

On top of the wing transom, on the exterior surface of the upper fashion piece, a standing knee, BAT 6357, reinforced the transom and hull planking on the side of the ship. Only partially preserved, it measures 1.17 m in length, 76.8 cm in width, and 27.8 cm in thickness (see fig. 4-67). It was fastened to the hull planking and wing transom by at least five iron bolts but not to the upper fashion piece.

TRANSOM BEAMS

Batavia's transom was reinforced by five transom beams below the wing transom, all of which were placed parallel to one another at intervals of roughly 25 cm (nearly 1 Amsterdam ft). Only the three lowest transom beams, BAT 6374, BAT 6261, and BAT 6262, have been preserved from the transom's exterior edge to the sternpost. Bolt holes at the forward end of the sternpost suggest that these transom beams were notched on their after faces to fit over the sternpost (see fig. 4-67).

The lowest transom, BAT 6374, was not seated in the fashion piece but was fastened on top of its lower end and is thus wedged between the fashion piece and sternpost. Its preserved dimensions measure 79.6 cm in length, 26.9 cm sided, and 26.9 cm molded.

As described previously, the four transom beams between the lower transom and wing transom were dovetailed into the fashion piece (figs. 4-67 and 4-72). They are preserved over lengths varying from 1.71 to 2.19 m, measure between 32 and 41 cm sided, and 36 and 41 cm molded. The second transom beam below the wing transom, BAT 6365, comprises the deck transom beam (see fig. 4-67).

TRANSOM KNEES

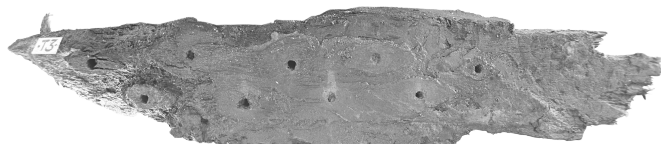
Five large lodging knees, called transom knees, reinforce *Batavia's* transom assembly. The uppermost knee was fastened to the wing transom, and the four below it to the transom beams (fig. 4-73). They are placed on top of the ceiling planking on the side of the ship's hull, which means they were installed after the frames and ceiling planks were inserted. Only the lowest transom was not reinforced with a knee. The transom knees were fastened to the transom beams and to the ship's side timbers with large iron bolts. None of the transom knees has been preserved in its entirety, and all are worm-eaten on either end.



BAT 6358, interior



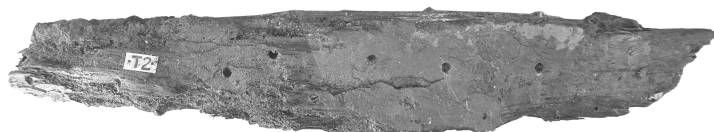
BAT 6358, bottom



BAT 6365, interior



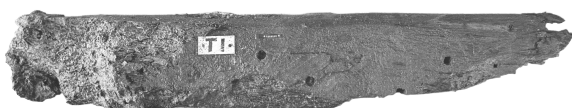
BAT 6365, bottom



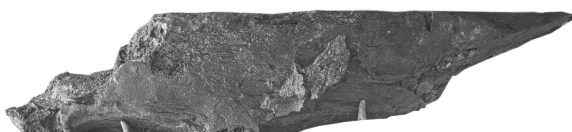
BAT 6364, interior



BAT 6364, bottom



BAT 6361, interior



BAT 6361, bottom



FIGURE 4-72. Transom beams. Photographs by Patrick Baker, Western Australian Museum (MAo415-31, MAo415-34, MAo415-35, MAo415-36, MAo416-05, MAo416-06, MAo416-07, MAo416-12, and MAo416-13).

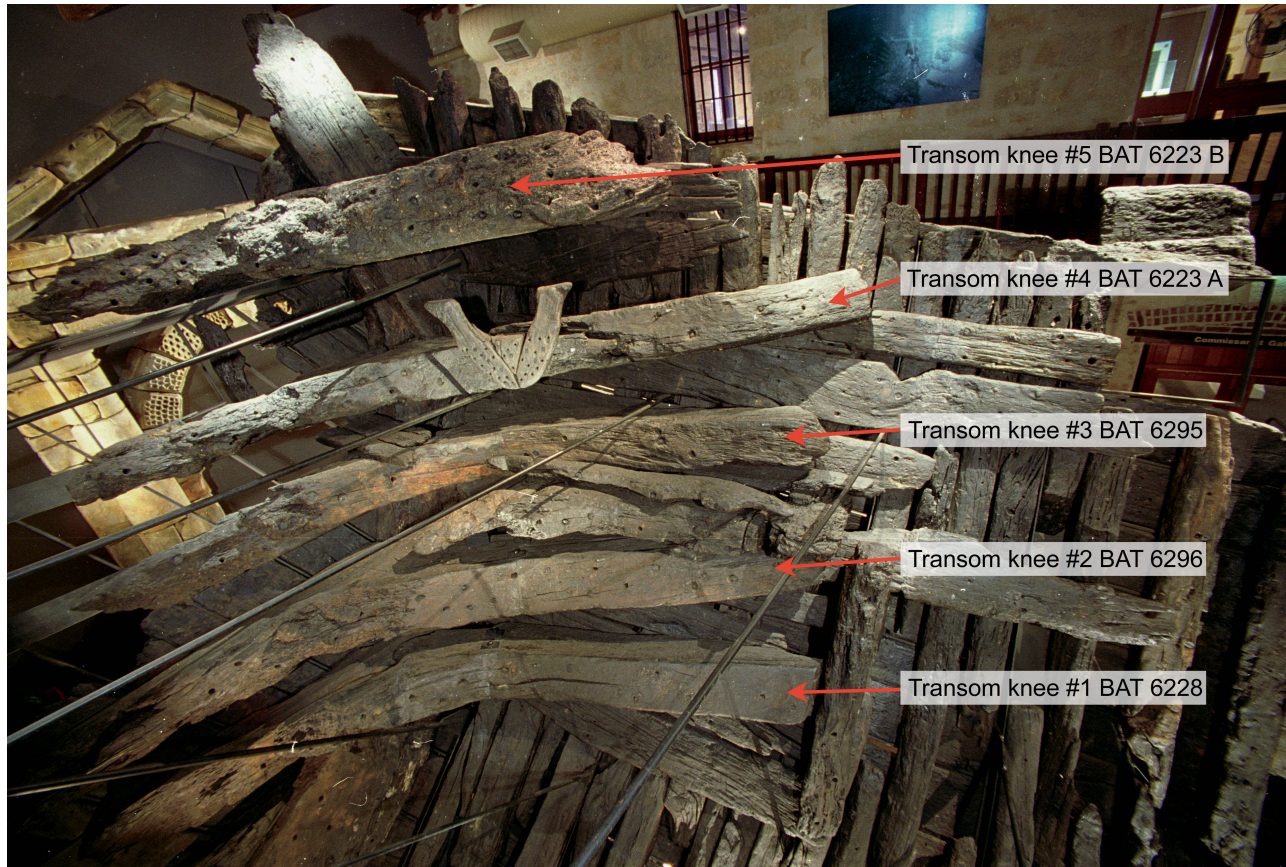


FIGURE 4-73.
Five transom knees
displayed in the
Western Australian
Museum—Shipwreck
Galleries. Photograph
by Patrick Baker,
Western Australian
Museum (MA5049-30).

The measurements for the length of the transom knees were aligned between the tips of their ends (fig. 4-74). Furthermore, their thickness is measured from their exterior corner, where the two arms intersect, to their inner corner. They vary in preserved length from 2.65 to 3.60 m, from 35 to 36 cm in width, and from 31 to 62 cm in thickness.

The transom knees were notched at the exterior intersection of their arms to fit over the fashion piece and upper fashion piece. Additionally, the shipwrights adjusted the shape of the uppermost transom knees, as the exterior faces of both knees did not follow the curvature of the ship's hull, and, therefore, large wedges were inserted between the knee ends and ceiling planking to ensure a tight fit (see figs. 4-74 and 4-75).

KEVEL

One kevel, or belaying cleat, has been preserved attached to the uppermost transom knee on the after lower deck directly below the wing transom, where it was fastened to the interior corner of transom knee BAT 6223 A with iron spikes (see figs. 3-2, 4-73, and 4-76). The kevel, BAT 6220, is made up of three oak sections, and the entire assembly measures 86 cm in length, 55 cm in width, and 8.8 cm in thickness. It was mainly used to belay the stern mooring line or tow line for *Batavia*'s boat.

DECK BEAMS, KNEES, AND PLANKING

Only fragmentary timbers from *Batavia*'s lower deck and one remnant of a hanging knee from the upper deck have survived. The timbers of the lower deck include one

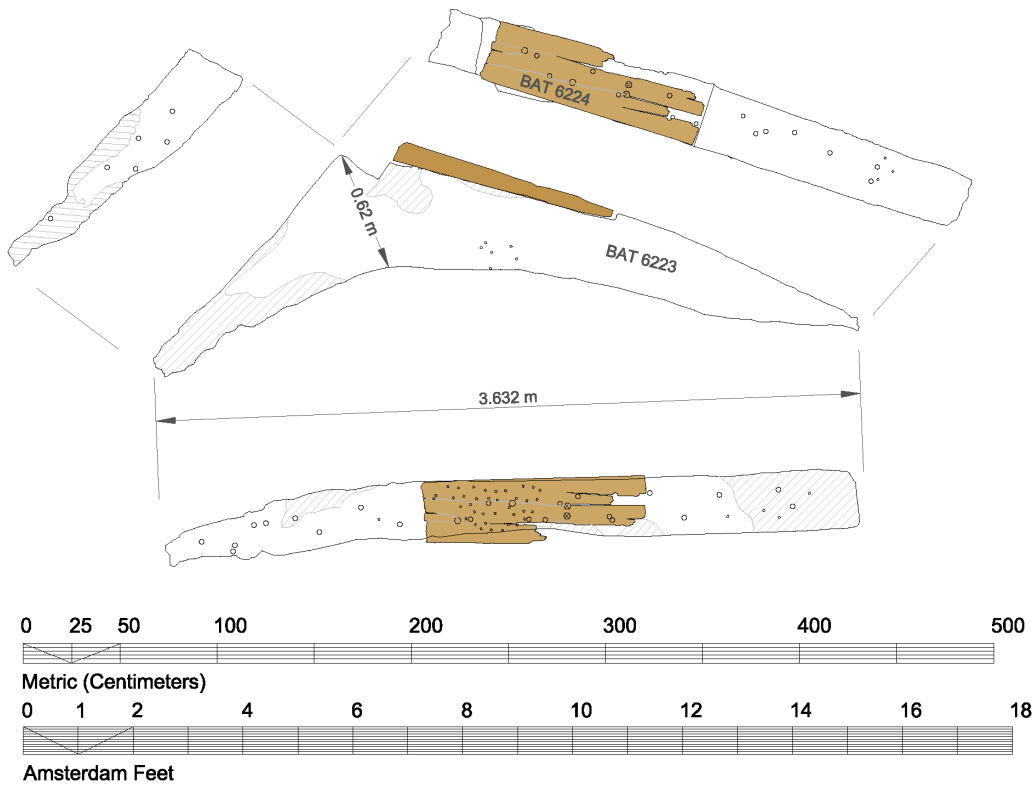


FIGURE 4-74.
Transom knee #4 and
its wedge (*highlighted
in brown*). Illustration
by author.



FIGURE 4-75.
View of top surface of
uppermost preserved
transom knee and its wedge,
BAT 6223 B. Not to scale.
Photograph by Brian Richards,
Western Australian Museum
(MA3294-01).

fragment of a hanging knee, a lodging knee, waterway, possibly a margin plank, and two fragmentary deck beams (fig. 4-77).

The hanging knee, BAT 6227, is poorly preserved and is missing its upper horizontal arm. It measures 1.52 m in length, 24 cm sided, and 30 cm molded. Directly above and forward of BAT 6227, the lower vertical arm of a hanging knee from *Batavia*'s upper deck was found (BAT 6130, not on display). It measures 1.97 m in length, 27.6 cm sided, and 30.5 cm molded. The lower end of the upper hanging knee slightly overlaps the horizontal arm of the lower hanging knee (see fig. 4-22). Aft of the lower hanging knee, the remaining stump of the foremost deck beam, BAT 6230, protrudes from the shelf clamp. This deck beam was notched at its lower end and slotted into the shelf clamp, like the

FIGURE 4-76.

Kevel, or belaying cleat, at aftermost end of lower deck, BAT 6220. Illustration by author.

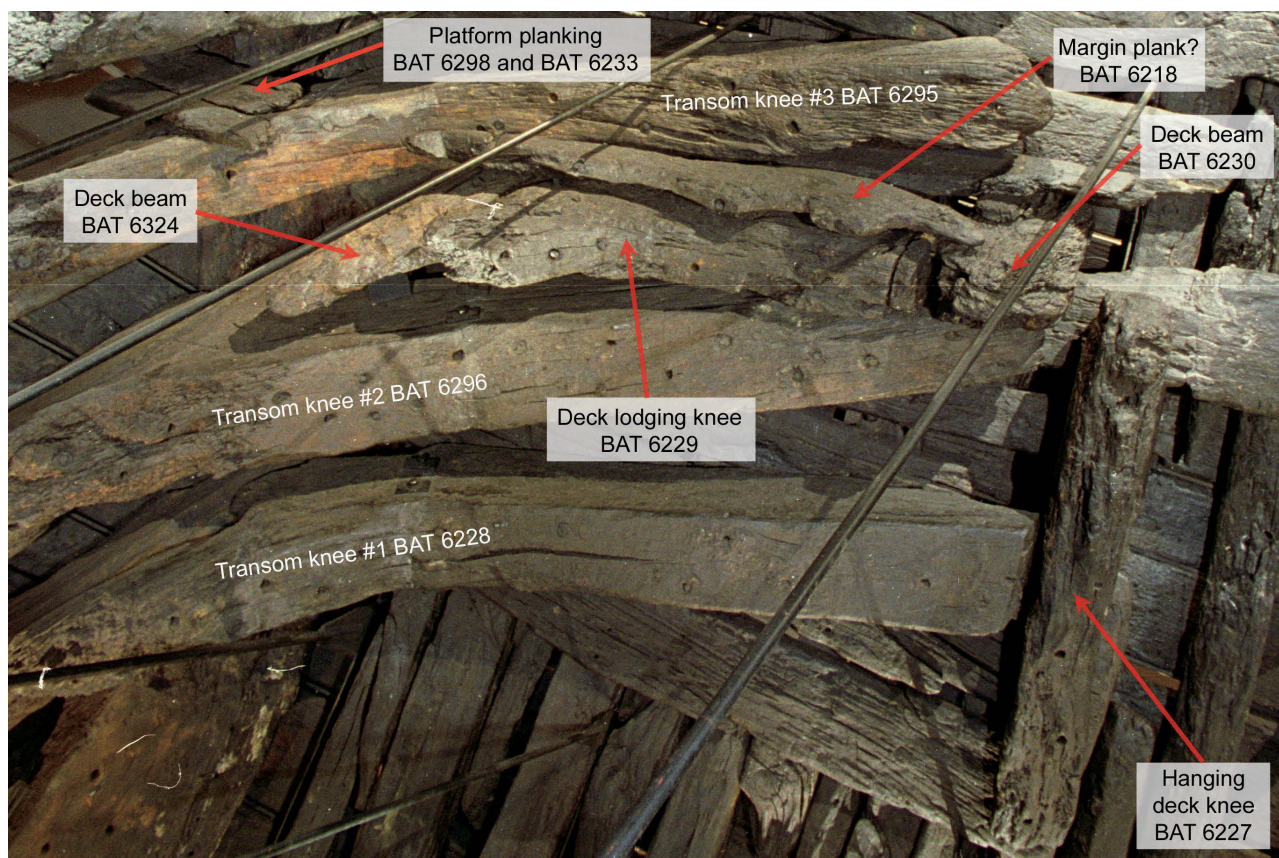
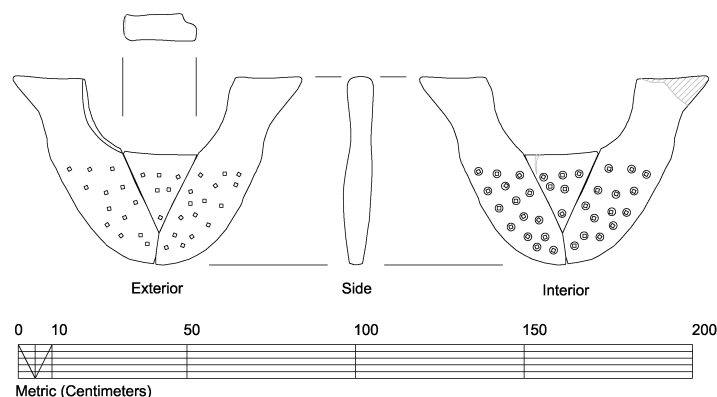


FIGURE 4-77. Deck timbers as displayed in the Western Australian Museum—Shipwreck Galleries. Photograph by Patrick Baker, Western Australian Museum (MA5049-30).

aftermost preserved remnant of deck beam BAT 6324. Between the two deck beams, one deck lodging knee, BAT 6229, has been preserved. The knee measures 1.49 m in length, 49 cm sided, and 28 cm molded (fig. 4-78). The timber was beveled on the exterior and aftermost edges of its top surface, probably to receive the waterway along the ship's side and transom. The knee was bolted to the ship's side, and its ends were fastened longitudinally to the deck beams. The forward end of this lodging knee rests on the forward arm

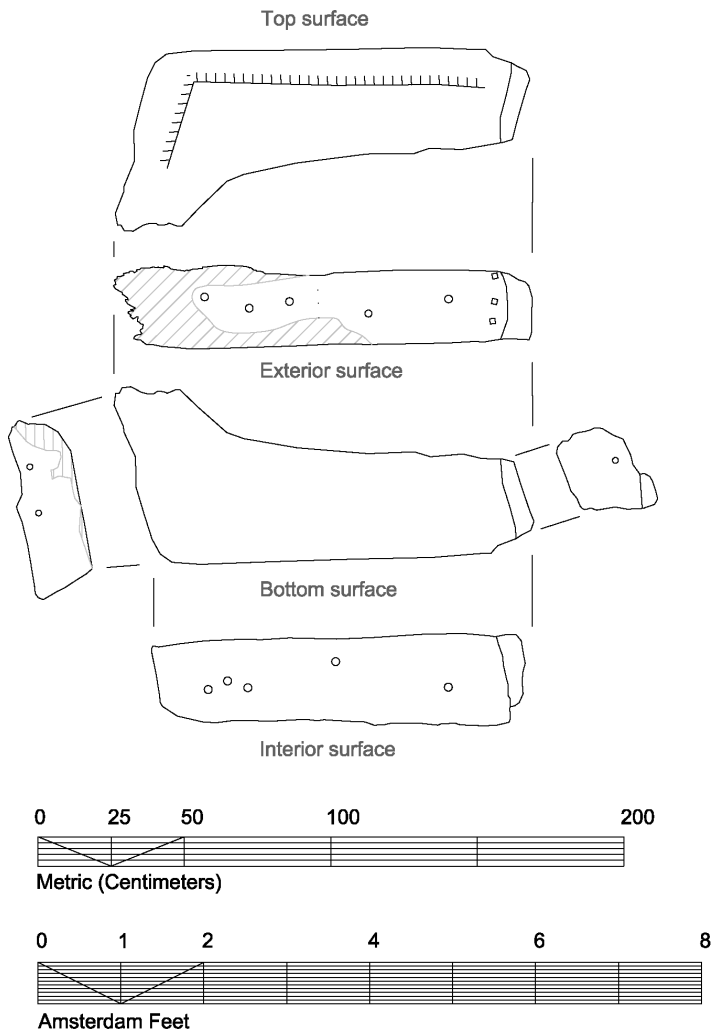


FIGURE 4-78.

Deck lodging knee, BAT 6229.

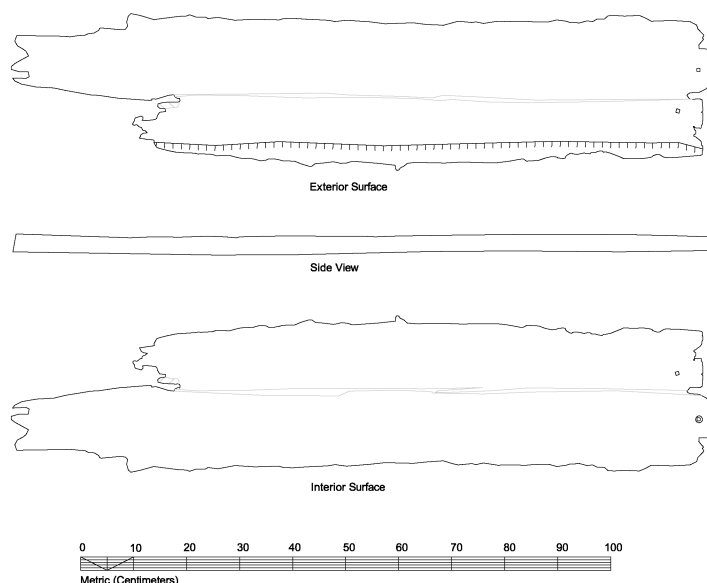
Illustration by author.

of the transom knee below, BAT 6296, whereas the after end of the transom knee above, BAT 6295, rested its aftermost face on the after deck beam.

Little of the lower deck's waterway has been preserved. One fragment, BAT 6231, demonstrates that it was merely a thick deck plank against the side of the ship. It is preserved over 1.174 m in length, 22.9 cm in width, and 10.7 cm in thickness (not illustrated). In addition, a fragment of a possible margin plank, BAT 6218, or other type of timber survived parallel to the waterway and the ship's side (see fig. 4-77). It was fastened to the waterway with iron bolts (2.3 cm in diameter). If a margin plank, its function was to prevent the straight deck planks from being tapered to a fine angle where they met the curvature of *Batavia*'s side at the after end of the hull. A margin plank is fashioned to receive the after- or foredeck planking ends. The timber on *Batavia* has the same thickness as the waterway (10.7 cm). The preserved fragment measures 1.7 m in length and 31 cm in width. No deck planking from *Batavia*'s lower deck has survived, and it may well be that the after end of the lower deck was not planked but raised to create the platform above it with spacing blocks on top of the deck beams, as also seen on *Vasa* (1628).⁸⁵

In addition, two fragments of one pine plank, BAT 6221 and BAT 6222, have survived.

FIGURE 4-79.
Planking from area in between
transom knees #3 and #4.
Illustration by author.



The fragments were found near the deck timbers during the shipwreck's excavation, albeit between transom knees #3 and #4; therefore, they were not part of the deck (fig. 4-79). As their exact location and orientation were not recorded, their function cannot be determined; they might be part of the ceiling planking's cargo floor above transom knee #4. The preserved plank measures 1.32 m in length, 29 cm in width, and 3.6 cm in thickness.

On top of the after arm of the third transom knee, BAT 6295, parallel to the transom, two oak planking remains run in a longitudinal direction. They are not deck planking but planks of a platform that rested on this transom knee and probably supported the two transom cannon (see figs. 4-67 and 4-77). The oak planking fragments vary in thickness between 7 and 7.5 cm.

FASTENINGS

Fastenings found in *Batavia* were made of wood, iron, and copper. Most of the wooden and copper fasteners are still present, whereas the majority of the iron fasteners did not survive. The inner layer of hull planking and the frame timbers of the ship's bottom were assembled by treenails driven in from the exterior and pegged in place with square tapering wooden pegs (see figs. 4-19 and 4-20). These treenails were probably also wedged on their interior, although no evidence of this practice has been found to date. The treenails have an average diameter of 32 mm, although they tend to be 1 or 2 mm larger in diameter on the planking's external face than on the interior. Treenail pegs vary in width from 1.5 to 2 cm in width and taper to a point. Generally, three treenails were inserted in a staggered pattern along each plank. This fastening pattern can be seen clearly on inner hull planks BAT 6030, 6031, and 6192 (see fig. 4-10).

Iron spikes were used mainly to fasten the outer layer of hull planking to the inner planking, and the upper strakes of hull planking, ceiling planking, and aftermost 2 m of the inner layer of hull planking to the frames. The ceiling and hull planks were generally fastened with three staggered iron spikes along the planking width; the ceiling planks were nailed down with spikes at every other frame, whereas the hull planking was fas-



FIGURE 4-80.
Top view (with wood
attached) and side view
of replica from iron
bolt concretion, BAT
3550 R. Photographs by
Patrick Baker, Western
Australian Museum
(MA0241-32 and
MA0241-33).

tened to each frame timber. Narrow planks were fastened with only one or two spikes. As discussed previously, the after end of the double layer of hull planking showed that the slight overlap between the inner and outer layers of hull planking facilitated a staggered nailing pattern at a regular interval along the planking's width. All iron spikes had square shanks that tapered to a point and averaged 1.5 cm in section below the heads. The precise length of these fasteners is unknown, but they could have easily been 16 cm or longer.

Impressions of the spike heads were visible in the countersunk holes in the timbers, showing they were roughly circular in section. The diameters of the spike heads vary from 2.3 to 3 cm, with an average of 2.5 cm. A few square spike heads have been found on the exterior of the surface of the hull planking, but the function of these particular nails is unknown.

The largest fasteners used for *Batavia*'s construction are iron bolts. They were mainly used to secure riders to the ceiling, frames, and hull planking. No riders have been preserved, but the bolt holes to fasten them are still present in other timbers. Round bolt holes are primarily found in *Batavia*'s second futtocks, indicating that the riders had the same average room and space of 41.4 cm. These bolts could easily have measured more than 60 cm in length, considering *Batavia*'s planking thickness, molded frame dimension, and ceiling planking thickness. The shanks of the bolts were round in section with consistent diameters of approximately 2 cm. They were inserted from the exterior of the hull where their large heads rested on the exterior of the hull planking. The bolt heads were roughly circular in section and peened at their tops (fig. 4-80). Generally, one or two bolts were used in each hull plank for every second futtock. The pine sheathing planks had cutouts to accommodate the large bolt heads. The diameter of the bolt heads seems to vary between 3 and 6.4 cm.

Additionally, bolts were employed to fasten the knees, transom beams, fashion piece timbers, and the upper gudgeon of the sternpost. The bolts used for the assembly of the transom timbers vary in diameter but generally measure 2 or 3.2 cm. Their heads have left countersunk impressions that are similar in diameter to those of the riders.

Iron filling nails, all similar in dimension and fastening pattern, were used to fasten the pine sheathing to the exterior of *Batavia*'s hull planking, to the interior of the gun port lid, and to the ship's sternpost. The square nail holes left behind in the pine sheathing and underlying hull planking indicate that the nails were fastened at intervals of about 5 cm in a quincunx pattern (see fig. 4-41). These closely set nails do not have a particularly large head, for the circular countersunk impressions of the nail heads have an average diameter of 1.5 cm. The nail shanks were square in section, measured 6 mm in cross section directly below the nail head, and then narrowed to 5 mm. Their tips tapered to a point. The filling nails were about 6 to 7 cm long and were therefore too large to be considered tacks.⁸⁶ Copper sheathing tacks were used exclusively to fasten the copper sheathing around *Batavia*'s sternpost.

TOOL MARKS

Saw and adze marks were well preserved on the interior and exterior surfaces of numerous planking strakes on *Batavia*'s hull. They were most evident directly after the timbers were raised from the seabed.

Irregular saw marks seen in the excavation timber photographs and on the conserved hull planking clearly indicate that all planks were hand-sawn with a framed pit saw, not cut mechanically by a wind-driven sawmill (see figs. 4-36, 4-81, and 4-82). It is not surprising that the *Batavia* ship's timbers were sawn by hand, given the resistance of the Amsterdam hand-sawyers guilds in the early seventeenth century against the introduction of wind-driven sawmills.

Some of *Batavia*'s timbers seem to have regular saw cuts that can easily be misinterpreted as being sawn by a wind-driven sawmill (fig. 4-83). The distance between the saw cuts demonstrates that the timber was fed through the mill at a tempo that would create a cut of 5 to 9 mm. This tempo is beyond the capacity of a seventeenth-century sawmill. Furthermore, when the lines of the saw cuts are traced on paper and continued with a pencil, they are not parallel. They are, therefore, sawn by hand. A well-trained pit sawyer could saw smaller timbers easily with a speed that creates saw cuts with a distance between 5 and 9 mm.⁸⁷

On a map of Amsterdam by Cornelis Anthonisz dating to 1544, two teams of sawyers

FIGURE 4-81.
Saw marks of framed pit saw
on interior surface of outer
hull planking, BAT 6106, strake
12. Photograph by Patrick
Baker, Western Australian
Museum (MA0188-26).

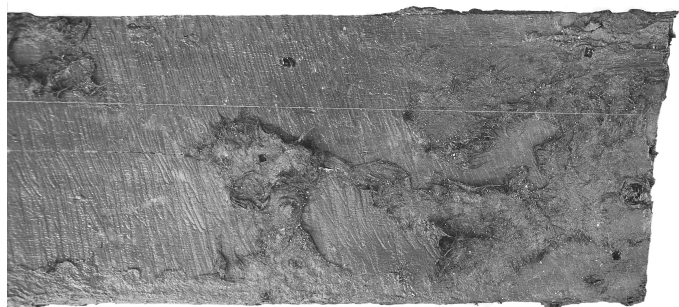




FIGURE 4-82.

Outer layer of hull planking with saw marks of framed pit saw on BAT 6078, strake 13 (*top*); and adze marks on BAT 6106, strake 12 (*bottom*). Photograph by Patrick Baker, Western Australian Museum.



FIGURE 4-83.

Regular saw marks of framed pit saw on side of an inner transom plank, BAT 6414. Photograph by Patrick Baker, Western Australian Museum (MAO420-06).

working a pit saw in the Amsterdam shipyards depict this method of sawing. Another example is a print on lottery tickets, dating to 1558, issued to fund construction work on the choir of the Old Church in Amsterdam (fig. 4-84).⁸⁸ In the second half of the seventeenth century, timber was apparently still sawn manually, as can be seen on a contemporaneous drawing by Reinier Nooms (fig. 4-85), even though the wind-driven sawmills had taken over.

Some hull planking surfaces show well-preserved saw marks, whereas others were deliberately smoothed by adzes (see fig. 4-82). The latter had their final shape established with adzes; adze marks are evident on all layers of hull planking (see figs. 4-36 and 4-82). The adze marks vary in size between 5.9 and 11.4 cm, with an average of 9.2 cm. The specifics of the adze and saw marks on the curved transom planking have been discussed previously. Tool marks also show that the futtocks were shaped and finished with adzes.

FIGURE 4-84.
Two sawyers working a
framed pit saw. Lottery
ticket, Old Church
Amsterdam, 1548.



FIGURE 4-85.
Sketch of shipyard.
Engraving by Reinier
Nooms, 1650–64,
Rijksmuseum
Amsterdam (RP-P-
1881-A-4735).



BATAVIA'S PLANKING ROT

Suspected charring on several of *Batavia*'s hull planks was observed during the wreck's excavation and would seem to have confirmed the use of an open fire to bend the ship's planks into shape. This method of shaping planks is seen in several depictions from the seventeenth century (see fig. 4-85).⁸⁹ Furthermore, charred surfaces have been reported on the bow and stern planking of the Christianshavn B&W 1.⁹⁰

On *Batavia*, the areas of so-called charring are located on the interior face of strakes 11 and 12 in the inner layer of hull planking and on the interiors of strakes 1–3 in the outer layer of hull planking (see figs. 4-10 through 4-13). The alleged charring on the interior hull planking (strakes 11 and 12), however, is confined to areas directly underneath the frames (figs. 4-86 and 4-87). The staining matches the frames' sided dimensions precisely and, therefore, does not conform to more widely spread burn patterns typical of charring (see fig. 2-11).⁹¹

Robert Blanchette, from the Department of Plant Pathology at the University of Minnesota, examined one particular sample and observed that the wood cells appear decayed and collapsed (crushed together), similar to what is commonly seen in an advanced stage

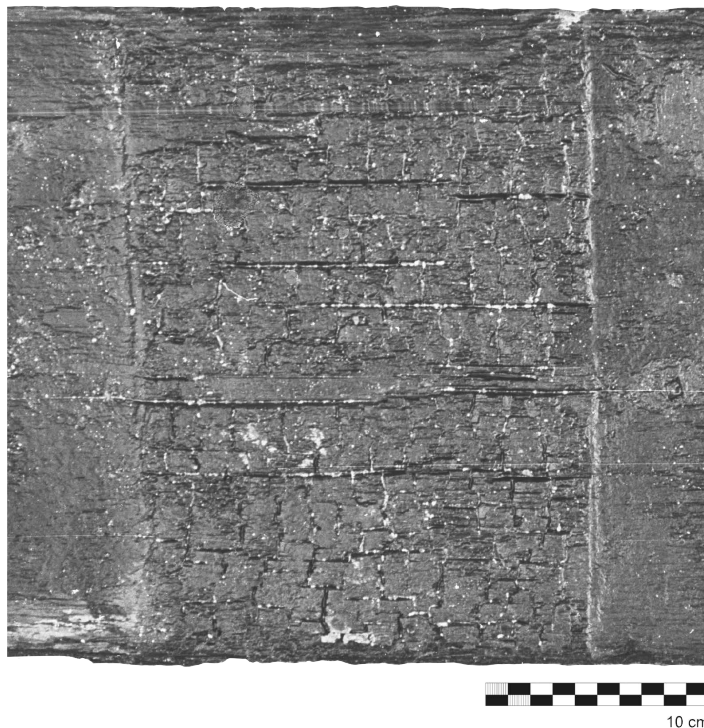


FIGURE 4-86.
Brown or soft rot around D2 and D3 labels on the interior surface of inner layer of hull planking, BAT 6395, strake 11, and BAT 6396, strake 12 (beneath frame C33, BAT 6328). Photograph by Patrick Baker, Western Australian Museum (MA0418-09).



20 cm

FIGURE 4-87.
Brown or soft rot on the
interior surface of inner layer
of hull planking, BAT 6097,
strake 12 (beneath frame
C20, BAT 6041/BAT 6065).
Photograph by Patrick Baker,
Western Australian Museum
(MA0186-06).

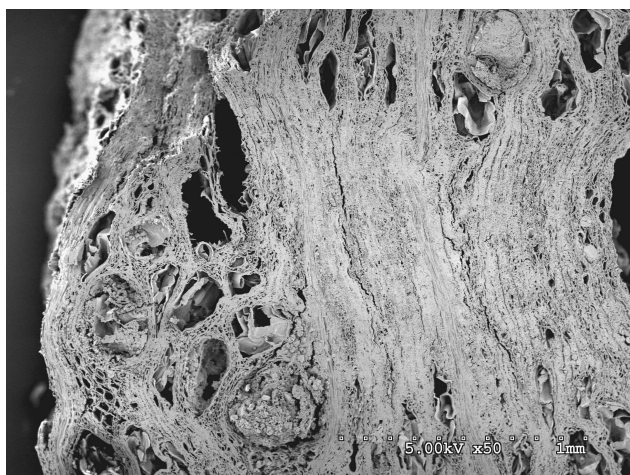


of brown rot (fig. 4-88a–c).⁹² It remains unclear, however, whether the damage was from brown rot or surface soft rot, which can also produce such dark stains. Micrographs of the exterior side of the sampled plank show a typical attack from bacteria but no fungal decay or cell compression (fig. 4-88d, e). Thus, the dark areas observed on *Batavia*'s hull timbers are more likely to be from brown or soft rot, which occurred within the ship's hull underneath the frames, than from charring (see fig. 4-87).

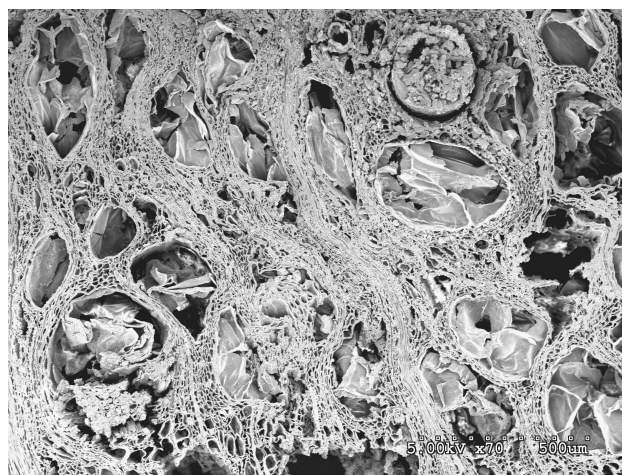
CONCLUSION

The construction features of *Batavia*'s hull clearly demonstrate that its shipwrights focused primarily on the ship's strength, waterproofing, and provision of the utmost protection against teredo worms. The ship's bottom hull is remarkably thick, as shown by the thicknesses and multiple layers of hull planking and pine sheathing. These multiple layers must not only have provided enormous strength but also added extra waterproofing because their seams had a slight offset, like overlapping roof shingles. The same can be said for *Batavia*'s ceiling planking, which was sealed off with an inner pine floor up to the lower deck. The multiple layers of the ship's planking, laminated together, would also have greatly strengthened the hull longitudinally.

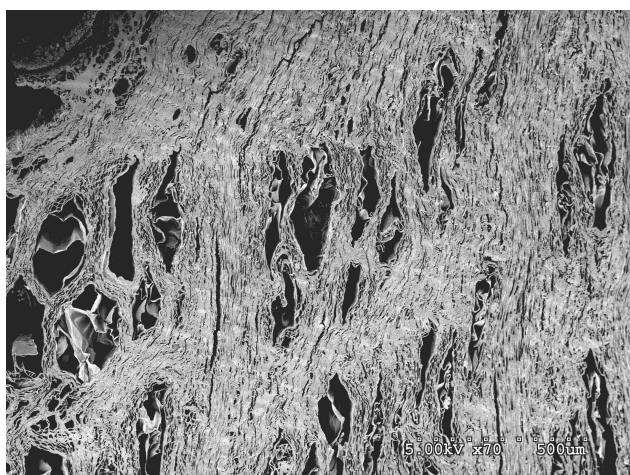
Layers of goat hair were applied with a resinous substance to all outboard surfaces of the hull planking, and some hair was also found on the outboard surfaces of the pine sheathing, to provide extra protection against teredo worms. The sternpost was encased in layers of oak, pine, copper, and hair, basically any method available, to protect it against teredo worms and impact damage, thereby reducing the risk of injury to this vital element. The galvanic corrosion caused by the iron nails of the protective planking and copper sheathing must have been problematic, despite the layers of goat hair in between.



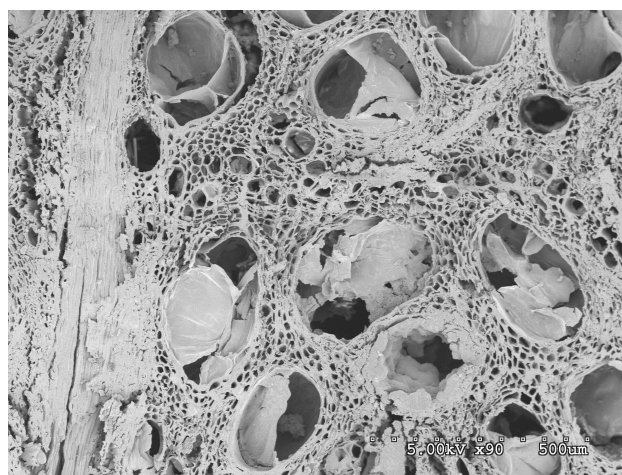
a



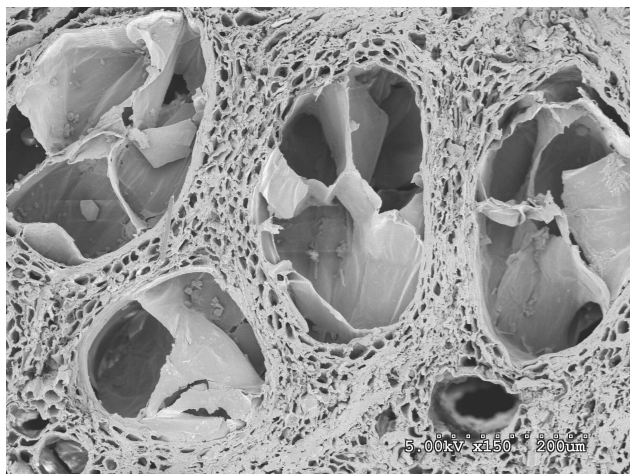
b



c



d



e

FIGURE 4-88.

Quercus petraea, BAT 6161, strake 1. Scanning electron microscope. (a–c) Brown or soft rot on the interior surface of outer layer of hull planking. (d–e) Exterior surface of inner layer of hull planking. Micrographs by Robert A. Blanchette, Department of Plant Pathology, University of Minnesota.

All measures, known or available, seem to have been taken to reduce any chance of the ship being weakened on its lengthy voyage to the Indies. The graving pieces and other construction features, such as the attachment of the sternpost's gudgeon to the transom, also indicate that *Batavia*'s shipwrights were meticulous and skilled craftsmen very capable of making the vessel's assembly shipshape.

In the following chapters, *Batavia*'s construction features are compared to archaeological examples of similar ships and to textual evidence from the late sixteenth and early seventeenth centuries. This provides a better understanding of what was considered standard practice by the VOC in the early seventeenth century and whether other VOC ships from this period were similar in construction to *Batavia*.

Batavia's hull structure also demonstrates that the strengthening or reinforcement of the ship's bottom was largely carried by the thick, multiple-layered skin, whereas the frames played a secondary role. This is concurrent with a bottom-based construction philosophy in which the bottom shell forms the foundation of the ship's structure. *Batavia*'s bottom-based construction method and building sequence is further delineated in chapter 8.

THE ARCHAEOLOGY OF DUTCH OCEANGOING SHIPS

5

The expansion of overseas trade and shipping during the sixteenth and seventeenth centuries increased the demand for the construction of ships in the Lowlands, particularly large oceangoing vessels. A comprehensive understanding of the Dutch shipbuilding tradition relating to these large seagoing ships during this period is difficult to achieve due to the limited contemporary written evidence and lack of well-researched (*and published*) archaeological data.

Generally, historical technological synthesis of shipbuilding can be achieved if a substantial body of shipwrecks from the same cultural origin, period, or region can be studied and compared. The archaeological study of hull structures from large oceangoing Dutch ships is, however, not easy for a number of reasons.

Typically, only a small portion of the hull structure is preserved on shipwreck sites. If fortunate, archaeologists find part of the ship's bottom up to the turn of the bilge; therefore, a full understanding of a ship's construction sequence from its keel to caprail is unrealistic to begin with, making ship reconstruction studies partially conjectural.

Nevertheless, the most complete data for late sixteenth- and early seventeenth-century Dutch shipbuilding is likely to be found in the remains of the ships themselves. As J. Richard Steffy and Frederick van Doorninck have demonstrated in the last decades, an in-depth study of a seemingly insignificant amount of hull wood can provide ample evidence to broaden our understanding of hull construction and shipbuilding tradition.¹

Unfortunately, this is exactly where study of Dutch ships becomes complicated, as valuable information has been destroyed over the last 50 years. Most postmedieval Dutch shipwrecks have been systematically plundered by looters or treasure hunters searching for artifacts with market value. The number of shipwrecks that have been found and excavated by archaeologists is small. The number of archaeological excavations that have been fully published in a scholarly manner is even smaller.

Approximately 50 VOC ships wrecked between 1606 and 1795 have been located to date (table 5-1). This number does not include any wrecks from, for example, the West India Company or Amsterdam Admiralty, such as Piet Heyn's *Hollandia* (West India Company, 1627), *Utrecht* (Amsterdam Admiralty, 1648), or *Curaçao* (Amsterdam Admiralty, 1727), all of which, incidentally, have been salvaged and their recovered artifacts sold by auction at Christie's in Amsterdam and Sotheby's in London. All that remains of the salvage of *Hollandia* and *Utrecht* are their auction catalogs.²

Of the VOC shipwrecks listed in table 5-1, at least 29 have been systematically destroyed by commercial salvagers, most *with* permission of the Dutch government. According to Article 247 of the Dutch constitution of 1789, the Dutch government became legal heir of the VOC after it was declared bankrupt in 1795 and, thus, owns all former

TABLE 5-1. VOC shipwrecks around the world

	Name	Location	Date	Tonnage	Output
1.	<i>Adelaar</i>	Barra, Hebrides, UK	1728	810	CS
2.	<i>Akerendam</i>	Ålesund, Norway	1725	850	CS
3.	<i>Amsterdam</i>	Hastings, UK	1748	1,150	AR
4.	<i>Avondster</i> (yacht)	Galle, Sri Lanka	1659	360	AR
5.	<i>Banda</i>	Mauritius	1615	600–800	—
6.	<i>Batavia</i>	Houtman Abrolhos, Australia	1629	600	AR
7.	<i>Bennebroek</i>	Mtana River, South Africa	1713	800	CS
8.	<i>Boot</i>	Salcombe, Prawle Point, UK	1738	650	CS
9.	<i>Brederode</i>	Cape Agulhas, South Africa	1785	1,150	CS
10.	<i>Bredenhof</i>	Strait Mozambique	1753	850	CS
11.	<i>Buitenzorg</i>	Waddenzee, Netherlands	1760	880	AR
12.	<i>Dolfijn</i> (yacht)	Galle, Sri Lanka	1663	520	AR
13.	<i>Domburg</i>	Meob Bay, Namibia	1748	850	CS
14.	<i>Geldermalsen</i>	Riau Archipelago	1752	1,150	CS
15.	<i>Geünieerde Provinciën</i>	Mauritius	1615	700	—
16.	<i>Hercules</i> (yacht)	Galle, Sri Lanka	1661	540	AR
17.	<i>Hollandia</i>	Scilly Isles, UK	1743	1,150	CS
18.	<i>Hoorn</i> (yacht)	Patagonia, Argentina	1615	110	AR
19.	<i>Huis te Kraaiestein</i>	Oude Kraal Bay, South Africa	1698	1,154	CS
20.	<i>Kampen</i> (yacht)	Isle of Wight, UK	1627	300	CS
21.	<i>Kennermerland</i>	Shetland Islands, UK	1664	950	CS
22.	<i>Lastdrager</i> (flute)	Shetland Islands, UK	1653	640	CS
23.	<i>Leimuiden</i>	Cape Verde	1770	1,150	CS
24.	<i>Lelie</i> (galliot)	Texel, Netherlands	1654	—	AR
25.	<i>Liefde</i> (frigate)	Shetland Islands, UK	1711	1,009	CS
26.	<i>Mauritius</i>	Gabon, Guinea	1609	700	AR
27.	<i>Merestein</i> (pinas)	Jutten Island, South Africa	1702	826	CS
28.	<i>Middelburg</i>	Cape Rachado, Malaysia	1606	600	CS
29.	<i>Middelburg</i>	Saldanha Bay, South Africa	1781	1,150	CS
30.	<i>Nassau</i> (yacht)	Cape Rachado, Malaysia	1606	320	CS
31.	<i>Nieuwerkerk</i>	Sulawesi, Indonesia	1748	1,135	—
32.	<i>Nieuw Rhoon</i>	Cape Town, South Africa	1776	1,150	AR
33.	<i>Oosterland</i>	Cape Town, South Africa	1697	1,123	AR
34.	<i>Prinses Maria</i>	Scilly Isles, UK	1686	1,140	CS
35.	<i>Ravestein</i>	Maldives	1726	800	—
36.	<i>Reigersdaal</i>	Springfontein, South Africa	1747	850	CS
37.	<i>Risdam</i> (flute)	Mersing, Malaysia	1727	520	CS
38.	<i>Rooswijk</i>	Goodwin Sands, UK	1740	850	CS
39.	<i>Slot ter Hoge</i>	Madeira	1724	850	CS
40.	<i>Vergulde Draak</i> (yacht)	Western Australia	1656	—	AR
41.	<i>Vis</i>	Tafelbaai, South Africa	1740	650	CS
42.	<i>Vliegend Hert</i>	Zeeland, Netherlands	1735	850	CS

TABLE 5-1. continued

	Name	Location	Date	Tonnage	Output
43.	<i>Voetboog</i> (flute)	Pernambuco, Brazil	1700	595	CS
44.	<i>Waddinxveen</i>	Cape Town, South Africa	1697	751	AR
45.	<i>Witte Leeuw</i> (yacht)	Saint-Helena	1613	540	CS
46.	<i>Zeelelie</i>	Scilly Isles, UK	1795	1,150	CS
47.	<i>Zeepaard</i>	Ireland	1665	400	AR
48.	<i>[Zee]rob</i>	Texel, Netherlands	1640	—	AR
49.	<i>Zeewijk</i>	Houtman Abrolhos, Australia	1727	850	AR
50.	<i>Zuiddorp</i>	Western Australia	1712	1,152	AR

* Commercial Salvage (CS) or Archaeological Research (AR). If the shipwreck was salvaged commercially in the past and archaeological research has been conducted since or it is now protected by a local cultural heritage act, it will still be referred to as CS, because the shipwreck has lost part of its intrinsic historic and archaeological value.

assets of the company. The Domain Directorate of the Dutch Ministry of Finance deputizes the government as owner of all buildings, land, objects, and real estate.³

The Ministry of Finance has issued about 50 salvage permits for VOC shipwrecks around the globe since 1967. This number is only an estimate, however, since no consistent documentation or filing system was kept that could have provided a precise number of shipwrecks and their identification. Since the early 1980s, thanks to the efforts of Thijs Maarleveld, former director of the Department of Underwater Archaeology of the Dutch Ministry of Welfare, Health and Cultural Affairs, no *new* salvage permits have been granted by the Ministry of Finance for shipwrecks within Dutch territorial waters (a zone of 12 nautical miles, or 22 km, from the coastline). This agreement, however, did not apply to salvage permits for shipwrecks outside Dutch territorial waters. In April 2002, the Ministry of Finance finally agreed to comply with specific archaeological standards when issuing new salvage permits or extending existing permits.⁴

The agreement was violated three years later, in 2005, when the Ministry of Finance issued a salvage permit to Rex Cowan's salvage company for *Rooswijk*. This large Dutch East Indiaman (850 tons) sank on its second voyage to the Indies on 8 January 1740 on the Goodwin Sands near Kent in the UK.⁵

Unfortunately, the precise extent of VOC shipwrecks worldwide will never be known because an indefinite number have been lost to future generations by for-profit discovery and salvaging. Dutch East Indiamen are desirable finds for commercial ventures, as they were bulk carriers of bullion such as coins and ingots. For this reason, they are specifically sought after by treasure hunters and are seldom random discoveries. Historic documentation has been a vital tool in aiding such ventures. Furthermore, shipwrecks of Dutch East Indiamen are often found in territorial waters of countries that have no legislation in place to protect their underwater cultural heritage, which makes the shipwrecks vulnerable to looters and salvagers. This is a sad state of affairs because these shipwrecks had the potential to add to our knowledge of ships and shipping in the late sixteenth to eighteenth centuries, information that cannot be found by archival or iconographic studies alone.

Although our current knowledge of Dutch shipbuilding in the late sixteenth and early seventeenth centuries has been limited, a particular Dutch shipbuilding tradition *did* exist for oceangoing ships traveling long distances over the oceans that can be better understood through a combined study of contemporary written sources and archaeological data.

This study of the Dutch shipbuilding tradition focuses primarily on large merchant ships from the late sixteenth to the mid-seventeenth century and includes vessels of the Dutch long-distance trading companies, *voorcompagnieën*, and the VOC. Analysis of their archaeological remains provides information about the bottom-based construction method, the use of double-hull planking, and the way the Dutch prepared their ships for voyages to distant and tropical waters.

Unfortunately, two well-preserved shipwrecks from this period, the yachts *Nassau* (1606) and *Witte Leeuw* (1613), have been commercially salvaged. The latter was salvaged in 1976 by Robert Sténuit in the waters of St. Helena. The yacht sank there after an encounter with two Portuguese carracks in 1613.⁶ Covered by 3 m of sand, the ship's well-preserved hull structure, consisting of the bow (about a third of the original hull) up to the lower deck with parts of the keelson, and about half of the keel were intact.⁷ Although most artifacts were sold by Christie's auction house, Sténuit did seem to have the intention to apply an archaeological approach to the shipwreck's salvage. In the earliest publication on *Witte Leeuw* in 1977, Sténuit mentions that the hull remains were recorded by photogrammetry and were being studied.⁸ A later publication in 1982 on the ceramic cargo of *Witte Leeuw* stated that the study of the ship's hull was ignored due a lack of workforce during five months of excavation—there were only four team members. It also stated that “the visibility on the site complicated photogrammetry,” suggesting this method to record the hull remains was abandoned as well.⁹

There is little published on the *Witte Leeuw*'s hull other than what can be seen in the *National Geographic Magazine* of October 1978, where hull fragments, broken off, are cast over the edge of a large crater dug into the seabed by the salvagers in search of valuable items such as Chinese blue and white porcelain, guns, diamonds, and gems.¹⁰ Furthermore, the visibility at the wreck site seems to be more than favorable for recording hull remains. The hull structure was, thus, not only ignored for study but also destructively removed.¹¹ Salvagers seeking artifacts with market value generally find the excavation, conservation, and study of hull timbers to be expensive, cumbersome, and time-consuming. This appears to have been the case with *Witte Leeuw*'s structural remains.

The hull remains of eight oceangoing vessels provide us with representative examples of late sixteenth- and early seventeenth-century Dutch shipbuilding. These ships range from small yachts of no more than 100 tons to large Indiamen of up to 700 tons. They are arranged first in chronological order and second by attributes, beginning with Dutch-built merchantmen *not* in service of the VOC, followed by those that may have been built by the Dutch or that have northwestern European construction features, and finally by ships in VOC service.

The oldest example is the fragmentary hull of a small yacht that sailed for one of the Dutch *voorcompagnieën* (1595–1602), which is also the only example of a ship belonging to the *voorcompagnieën* discovered to date. It was one of two unnamed ships used by Willem Barents in an attempt to sail to the Indies through the northern route in 1596. The names of both ships are unknown.¹² Other well-preserved examples of shipwrecks of

seagoing merchantmen are the Scheurrak SO1 (1590s) and Angra C (early seventeenth century). The hull remains of these shipwrecks are discussed according to their Dutch and non-Dutch origin first and then in their chronological order.

In addition to *Batavia*, one Indiaman and three yachts, all in service of the VOC, are subject to comparative study: *Mauritius* (1609), *Nassau* (1606), *Vergulde Draak* (1656), and *Avondster* (1659).¹³ These shipwrecks constitute the entire corpus of VOC shipwrecks dating before the second half of the seventeenth century for which at least some information is available on their hull remains. As it is not known precisely when all these ships were built, the dates of sinking are provided instead.

One additional Indiaman is discussed, although it was in service of the Danish India Company. The Christianshavn B&W 2 ship was presumably built in a Dutch shipyard sometime after 1606 and was in the service of the Danish East India Company until scuttled in Christianshavn around 1630.¹⁴ This study is limited to shipwrecks with reliable information on their hull structure or fragmentary hull timbers that have been published or are otherwise available for comparison.¹⁵

YACHT OF WILLEM BARENTS (1596)

The remains of a 100-ton yacht abandoned in 1596 were discovered in 1979 on a beach in Nova Zembla (modern-day Novaya Zemlya, an archipelago in the Arctic Ocean in the north of Russia) by amateur-archaeologist and engineer Dimitri Kravtsjenko. Kravtsjenko was conducting research near the remains of a house built by Dutch seamen who wintered on Nova Zembla in the winter of 1596–97 after their ship had become ice-bound. He uncovered a small section of the ship's hull after his metal detector indicated a high concentration of metal in the soil. Kravtsjenko had time to make only a quick and not-very-detailed drawing of the remains, then left the timbers exposed to the elements. Thirteen years later, they were transported to Moscow after an archaeological fieldwork campaign under the direction of Pyotr V. Boyarsky from the Russian Research Institute of Cultural and Natural Heritage.¹⁶

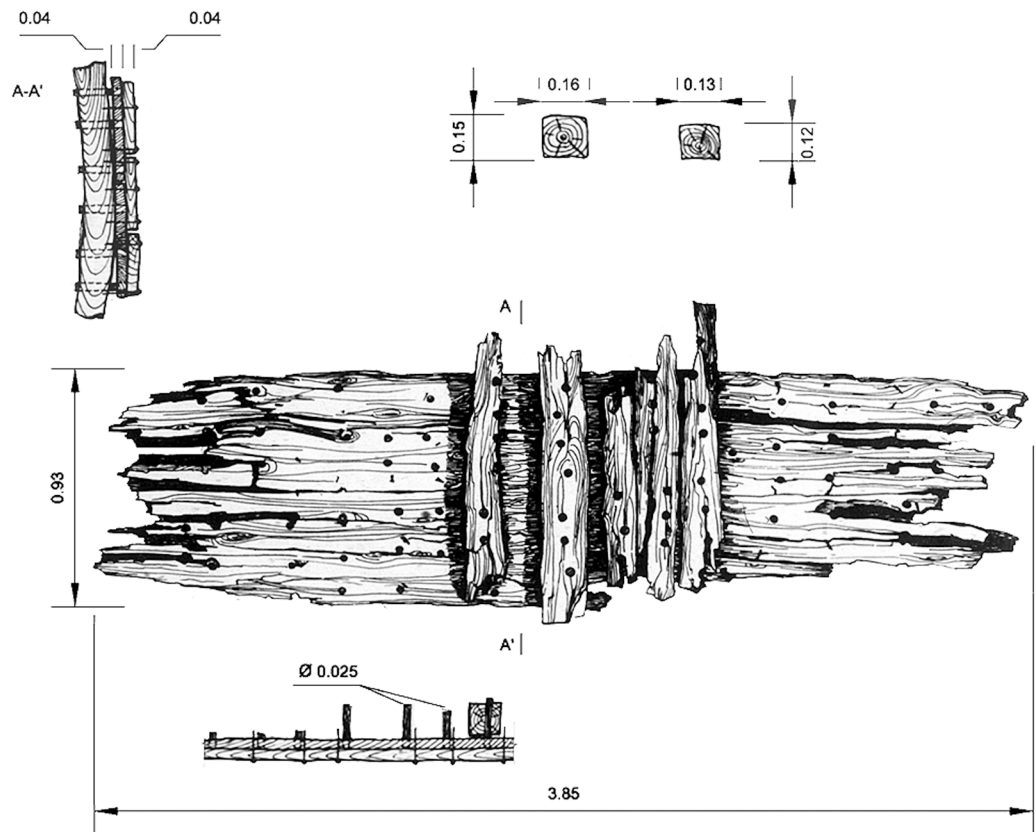
The Dutch sailors stranded on the northeastern coast of Nova Zembla had set sail to the Indies via the Open Polar Sea on 10 May 1596. It was the third Dutch attempt to open up this route to the Indies under command of Willem Barents and Jacob van Heemskerck. Their flotilla consisted of two ships whose names are unknown. Barents and Van Heemskerck sailed on a yacht of 100 tons, and their companion Jan Corneliszoon Rijp on a slightly smaller yacht of 60 tons. They were to open up the passage to the Indies that was thought to run straight through four islands around the North Pole.¹⁷ As they could not find this passage, Rijp returned to Holland and arrived in the fall of 1596, whereas Barents and Van Heemskerck continued searching for another route. After a tough, cold winter on Nova Zembla, the crew of the 100-ton yacht returned in the ship's boats on 29 October 1597.

The remains of the ship's hull are 3.85 m by 93 cm and consist of two fragmented stakes of hull planking and remnants of seven floors (figs. 5-1 through 5-3). The ship's hull planking is made up of two layers, which are roughly 40 to 45 cm in width and 4 cm in thickness (for a total thickness of 8 cm); the outer layer is fastened to the inner layer with iron nails.¹⁸ The floors are fastened to the first layer of hull planking with wooden treenails. No traces of an additional layer of pine sheathing were found, although this yacht was destined to sail to the Indies. Archaeologists suspect that additional remains of

FIGURE 5-1.
Possible hull remains
of Barents' ship
(1597), Nova Zembla.
Photograph by Jerzy
Gawronski/Moscow
Institute for Heritage.



FIGURE 5-2.
Hull remains of Barents'
ship. Not to scale.
After Russian Research
Institute of Cultural
and Natural Heritage,
Moscow.



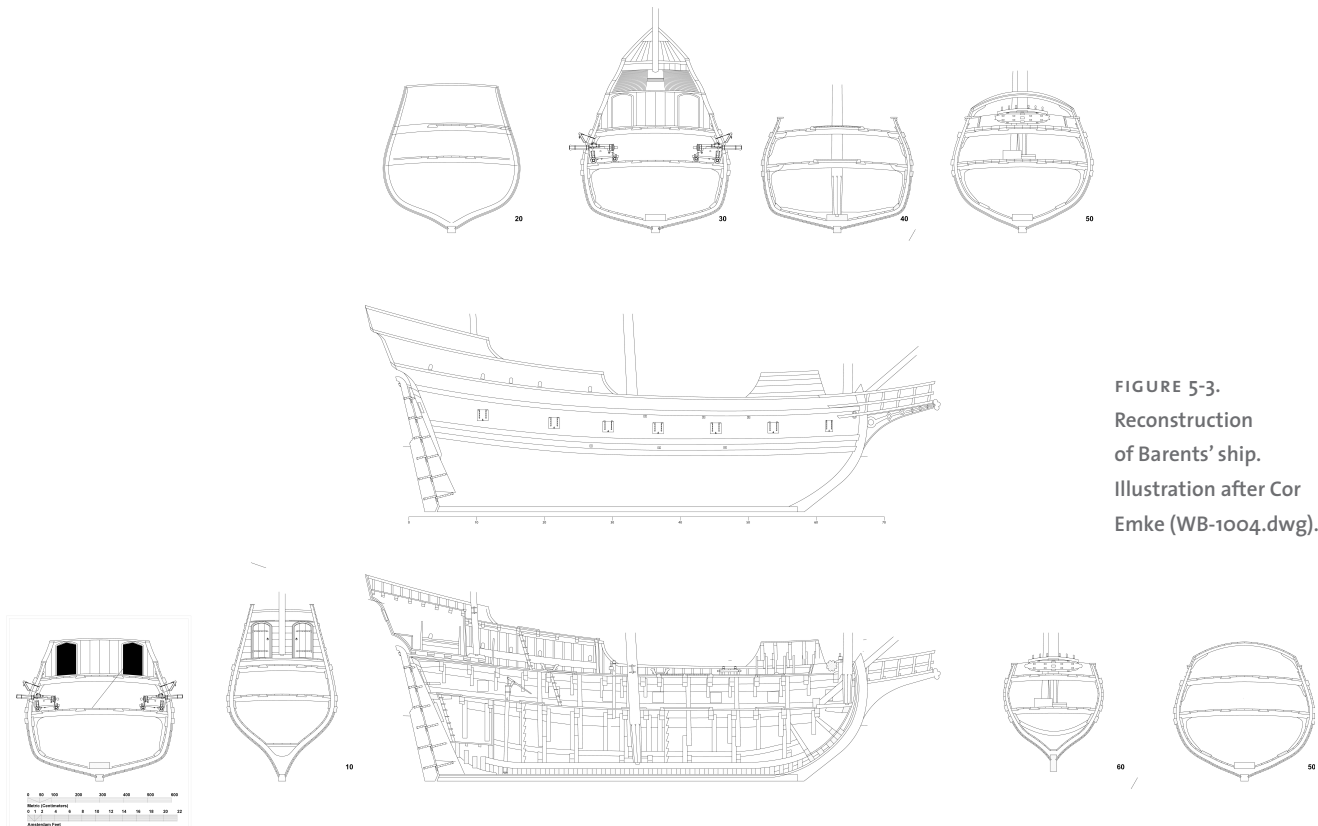


FIGURE 5-3.
Reconstruction
of Barents' ship.
Illustration after Cor
Emke (WB-1004.dwg).

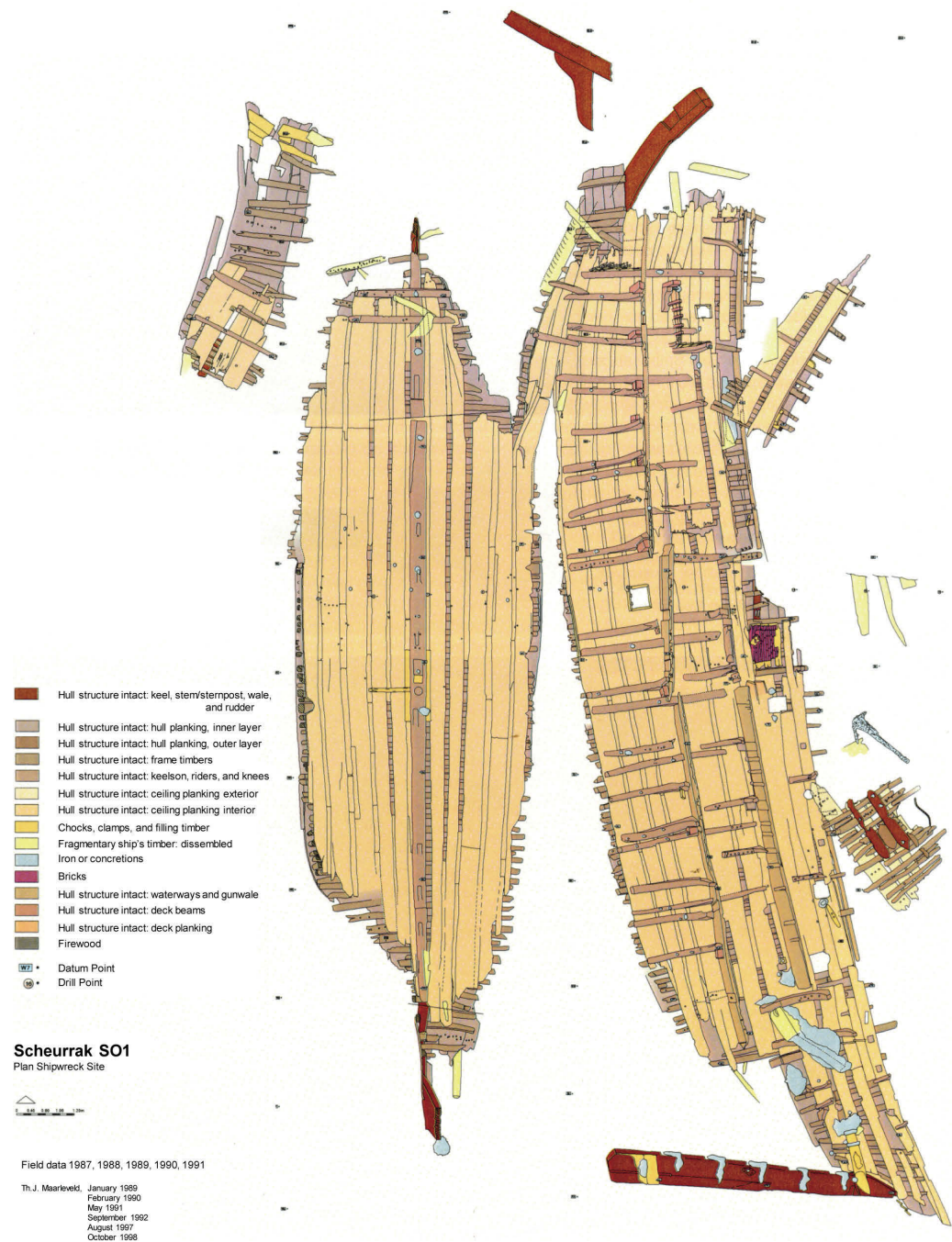
the ship's hull may be preserved underwater, several meters from the tide line against a longitudinal embankment close to where the original remains were found.¹⁹

MERCHANTMAN SCHEURRAK SO1 (1590S)

The Scheurrak SO1 shipwreck was discovered in 1984 in the Wadden Sea and excavated between 1989 and 1997 by the Nederlands Instituut voor Scheeps- en onder-waterArcheologie.²⁰ The large merchantman sank sometime after 1590, perhaps on 24 December 1593.²¹ On this particular Christmas Eve, around 150 ships were caught in a southwesterly storm on the Wadden Sea;²² more than 40 merchant vessels sank, and over 1,000 people onboard those ships lost their lives.²³ The location and orientation of the Scheurrak SO1 are in accord with a lee shore created by this storm. In addition, several artifacts date the ship to the 1590s, such as a trumpet engraved with "Lissandro Milanese Fecit Genoa 1589" and a linstock engraved with a poem signed by a gunner named Cornelis Claeszoon from Westblokker in the year 1590.²⁴

The hull is well preserved and includes most of the lower starboard hull up to the turn of the bilge, bottom planking, and parts of the bow and stern (fig. 5-4).²⁵ Part of the hull's starboard side, although separated from the lower hull, is preserved up to the bulwarks.²⁶ The total length of the vessel is more than 30 m (105 Amsterdam ft), which indicates the remains are of a large merchantman.²⁷ The hull consists of a double layer of oak planking. Both layers were rabbeted into the keel and have a total thickness measuring more than 14 cm (5 Amsterdam thumbs). The thickness of the two layers of planking is more or less equal (fig. 5-5). The floors and futtocks were fastened to the first layer of hull planking with wooden treenails and are not fastened to each other.²⁸ Unlike the inner layer of hull planking, built using a bottom-based construction method, the outer layer was added

FIGURE 5-4.
Site plan of Scheurrak
SO1 shipwreck, Wadden
Sea. Illustration by Thijs
J. Maarleveld, courtesy
of the Rijksdienst voor
het Cultureel Erfgoed
(Lelystad).



after the frames were inserted. It was temporarily fastened to the inner layer of hull planking with iron fasteners (approximately two per meter) and then securely fastened in place with treenails. These treenails were wedged on the interior and pegged on their exterior surfaces.²⁹ The oak ceiling planking was fastened to the frames and the first layer of oak hull planking with wooden treenails.³⁰ The double-rabbeted keel consisted of at least three flat-scarfed timbers and has a total length of 24 m (85 Amsterdam ft).³¹

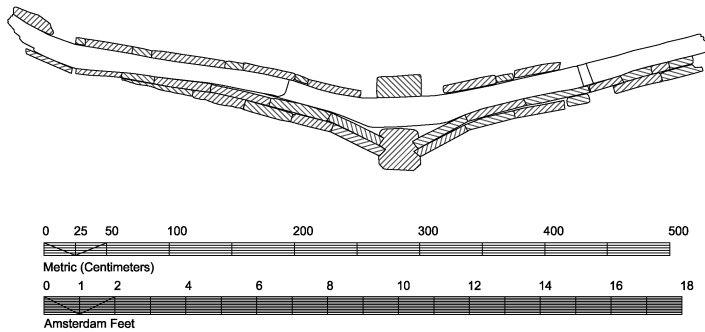


FIGURE 5-5.
Section of Scheurrak SO1 ship's
hull. Illustration after Thijs J.
Maarleveld, courtesy of the
Rijksdienst voor het Cultureel
Erfgoed (Lelystad).

DUTCH-BUILT DANISH EAST INDIAMAN CHRISTIANSHAVN B&W 2 (1630)

On the former location of the Burmeister & Wain (B&W) ship engine factory in the area of Christianshavn in Copenhagen, Denmark, the remains of eight ships were recorded and excavated in 1996 and 1997. Christian P. P. Lemée published his study of the ships in *The Renaissance Shipwrecks from Christianshavn*. Of the eight ships, six were dismantled and scuttled sometime before 1750 to form the foundation of a careening wharf.³² One of these ships, the so-called B&W 2 shipwreck, an early seventeenth-century Dutch-built East Indiaman, is of particular interest to this study.

The remains of the Christianshavn B&W 2 shipwreck comprise mainly the after half of the ship's wooden hull over an area of 14.5 m in length and 7.5 m in width, from abaft the mainmast step to its stern. The construction of this particular ship is dated to sometime after 1606 by dendrochronology.³³ It was built using a bottom-based construction method in the same manner as *Batavia*.

Lemée's study of the Christianshavn B&W 2 does not include a reconstruction with an estimated tonnage and proposed hull shape. He does indicate that the ship's hull must have had an overall length of 27.5 m and a maximum breadth of 7.5 m.³⁴

The ship's double-rabbeted keel timber, false keel, and keelson are all joined together with long iron bolts (diameter 2 to 2.2 cm). Its floors, futtocks, and first futtocks are not interconnected or transversally fastened but overlap each other at their ends to form a solid band of timber.³⁵

The ship has two layers of oak hull planking of approximately the same thickness (maximum 7.9 cm for the inner layer and 7 cm for the outer layer) and an additional layer of pine sheathing (maximum thickness of 2.5 cm) on their exterior.³⁶ Between the three layers a coating of animal hair and finely ground glass was applied to deter teredo worms; the coating was mixed in with tar to help seal the planking seams and to improve the ship's watertightness.³⁷

Like *Batavia* and all ships discussed in this chapter, the frames of the Christianshavn B&W 2 were fastened to the inner layer of hull planking with treenails that were pegged on their exterior faces. The outer layer of hull planking was secured to the inner layer with iron nails.³⁸ Similar to the fastenings in *Batavia*, each plank was fastened with rows of three staggered spikes across the planks at intervals of 40 to 50 cm along the strakes.

The outer layer of hull planking of the ship may have been a later addition based on its dendrochronology and its fastening to the inner layer by iron nails. The timber for the ship was felled in 1606, whereas the planking of the outer layer of hull planking was added between 1618 and 1625.³⁹ This use of iron spikes to fasten the outer layer of hull planking

to the inner layer is evident in the Barents yacht, *Mauritius*, and *Batavia*. Lemée adds that the outer layer of *Mauritius* and *Batavia* has no structural function, which is incorrect, because the second layer has the same thickness as the inner one and, as the *Mauritius* shows, was seated in the ships' keel rabbet.

The application of iron spikes to fasten the outer layer of oak hull planking was common practice by Dutch shipbuilders for long-distance trading ships, as clearly indicated by the Barents yacht, *Mauritius*, and *Batavia*. In fact, *Batavia* was originally constructed with a second layer of oak planking fastened to the ship's inner layer by iron spikes. As discussed in more detail in chapter 6, the outer layer of oak hull planking was often replaced several times over the life span of ships in service of the VOC.

Based on historic research and the Christianshavn B&W 2's bottom-based construction method, Lemée suggests that the ship may originally have been constructed in the Dutch Noorderkwartier.⁴⁰ Unlike *Batavia*'s hull planking, which was sawn manually, the Christianshavn B&W 2's hull planking was sawn mechanically. Thus, it was not constructed in an Amsterdam shipyard because the city had no wind-driven sawmills before 1630. It actually confirms that the Christianshavn B&W 2 was probably constructed in the Zaan region of the Noorderkwartier, where ship timber had been sawn by wind-driven sawmills since the late sixteenth century.

The Christianshavn B&W 2 and *Batavia* have many similarities, such as the occurrence of nail plugs on both interior and exterior surfaces of the hull planking. The exterior nail plugs indicate the use of shoring posts placed underneath the ships' hulls during their construction.⁴¹

Even though no *Batavia* riders have been preserved, the remnants of large iron bolts in the ship's hull planking indicate that its riders, like those of Christianshavn B&W 2, were fastened by bolts (diameter of shanks 2 cm). Another similarity between these ships is the use of copper sheathing on the aftermost end of the sternpost. This copper sheathing, fastened by copper tacks, was applied to avert marine organism attack of the hood ends of the sternpost planking or covering.⁴²

DUTCH-BUILT (?) MERCHANTMAN ANGRA C

Another early seventeenth-century merchantman built using a bottom-based construction method with a double layer of hull planking was found during construction of a marina in the port of Angra in the Azores. This shipwreck, named Angra C, was one of two contemporaneous shipwrecks excavated in about 7 m of water in this area by the Centro Nacional de Arqueologia Náutica e Subaquática (CNANS) in 1998. After the excavation of the Angra C and D shipwrecks was completed, their hull remains were dismantled and removed from the marina development area.⁴³ The hull remains of the Angra C were recorded and mapped under the direction of Kevin Crisman of the Nautical Archaeology Program of Texas A&M University in the summer of 2000. The structural remains of the ship were preserved over a length of 14.75 m and a width of 6 m. They include part of the ship's bottom hull and consist of the remains of the keel, keelson, rising deadwood, 6 strakes of inner hull planking and 5 of outer hull planking on the port side, 7 strakes of inner hull planking on the starboard, 20 floor timbers and 36 futtocks (18 on either side of the keel), 2 strakes of limber boards, 4 strakes of ceiling planking, and 2 bilge stringers (fig. 5-6).⁴⁴

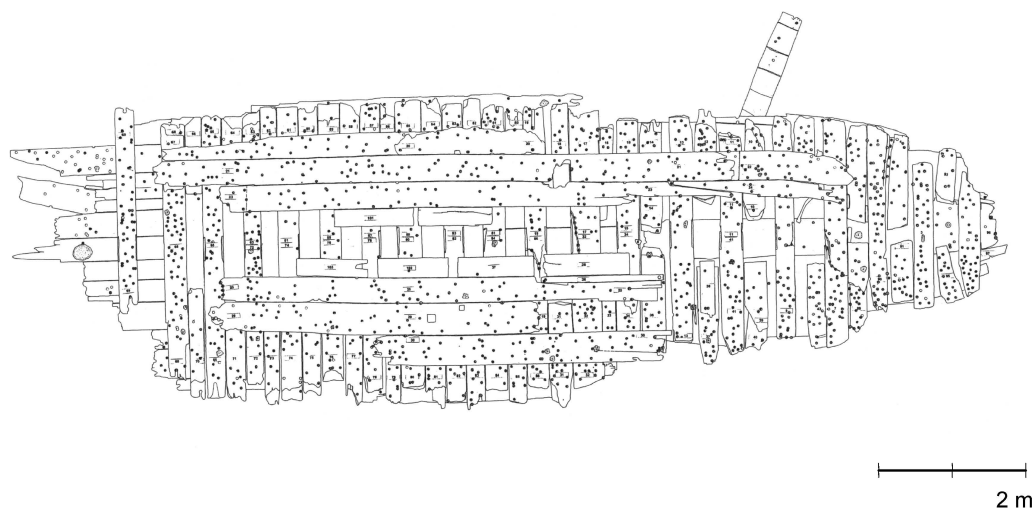


FIGURE 5-6.
Plan of the Angra C
ship's hull remains.
Illustration by Colin
O'Bannon.

Although the research on this vessel is far from complete and detailed hull drawings and scantling lists have yet to be published, Erik Phaneuf's study on the ship's hull remains, "Angra C, une épave Hollandaise en contexte Açoreen du XVIIe siècle," has produced some important and detailed information. Although Phaneuf has specified a bow and stern orientation, it is uncertain whether this identification is correct.⁴⁵ For clarity, Phaneuf's orientation is used in the following discussion, but it must be kept in mind that the preserved bow area may just as well be the ship's stern area.

Angra C's keel was made of several timbers, only one of which was preserved. Its present length is 8.40 m, which is not its original length, as the scarf tip at its after end is only partially preserved. A reconstructed length for this keel timber is 9.85 m. At its forward end, it joined the stem with a 1.4 m vertical scarf fastened transversely with 11 metal bolts (diameter of shanks 2 cm). This keel timber has no rabbets to receive the ship's garboard strakes but has chamfered edges that correspond with the thickness of the garboard stake (7 cm; figs. 5-7 and 5-8). The keel was molded 35 cm and sided 20 cm on its top surface.⁴⁶ The endposts have disappeared. The shape of the keel is not similar to that of other shipwrecks discussed here and is not characteristic of Dutch shipbuilding of the early seventeenth century. However, *spijkerpennen* found on the top of Angra C's keel and on the ship's hull planking indicate the ship was assembled by a bottom-based construction method.

The hull consists of a double layer of planking, which is preserved only on the ship's port side. Both layers of planking have a total thickness of approximately 14 cm (5 Amsterdam thumbs). As in the Barents, Scheurrak SO1, and Christianshavn B&W 2, the thickness of the two layers of hull planking is more or less equal (7 cm; see fig. 5-8).

The inner layer of hull planking has been preserved on either side of the keel (six strakes on port, seven on starboard). The planks vary in width between 25 and 50 cm, and in thickness between 6 and 8 cm. The only complete plank with a flat scarf on either end is 11 m long (strake 4 on the port side). The ends of the hull planking were joined together with flat scarfs or butt joints, although the latter predominate on the outer layer of hull planking (figs. 5-9 and 5-10). Planks were fastened to the frames with treenails with

FIGURE 5-7.
Preserved keel timber,
Angra C shipwreck.
Illustration by Erik Phaneuf.

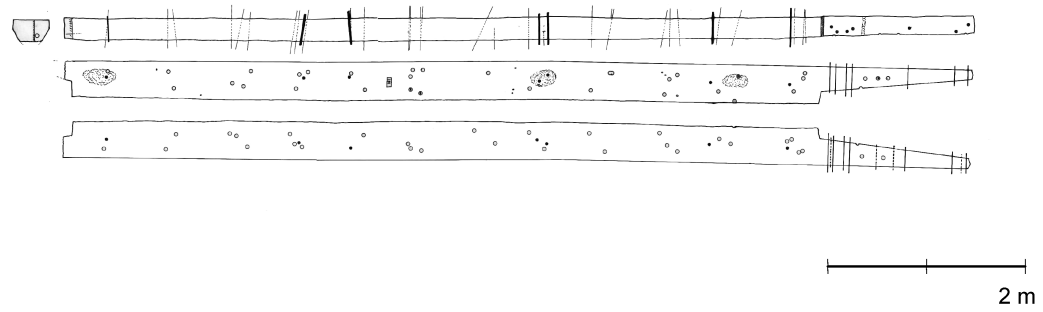


FIGURE 5-8.
Cross section showing
inner and outer layers
of hull planking, Angra
C shipwreck. Illustration
by Erik Phaneuf.

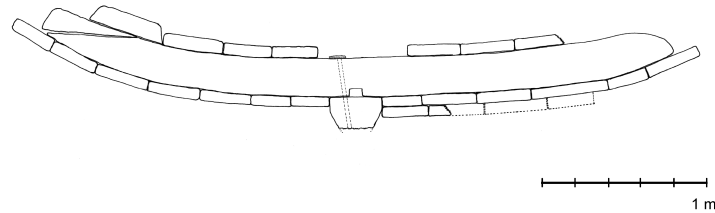


FIGURE 5-9.
Plan of inner layer of
hull planking, Angra C
shipwreck. Illustration
by Erik Phaneuf.

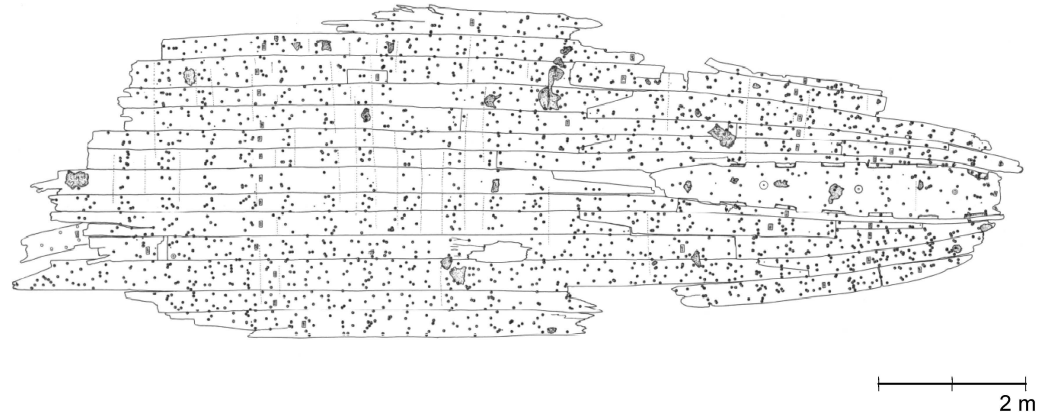
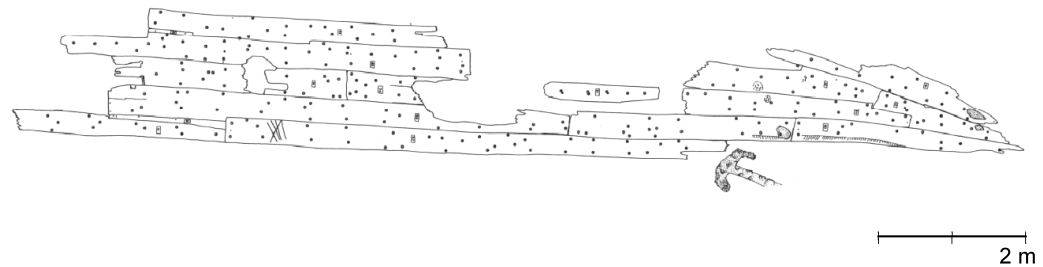


FIGURE 5-10.
Plan of outer layer of
hull planking, Angra C
shipwreck. Illustration
by Erik Phaneuf.



a diameter between 2.5 and 3.5 cm. Only two examples of wedged treenails were observed. Although the outer layer of planks was fastened primarily with treenails (two to three treenails per plank, per frame, as in the Scheurrak SO1), the plank ends were fastened to the inner layer with iron nails.⁴⁷

Twenty preserved floor timbers cross over the ship's keel, 18 of which are still accompanied by first futtocks on either side of the keel. The room and space of the floor timbers measured between 50 and 70 cm. Floor timbers were sided between 24 and 55 cm, with an average of 32 cm. Their average molded dimension is 25 cm. The length of the floor timbers varies between 1.46 and 4.4 m. Ten floor timbers were fastened to the keel and

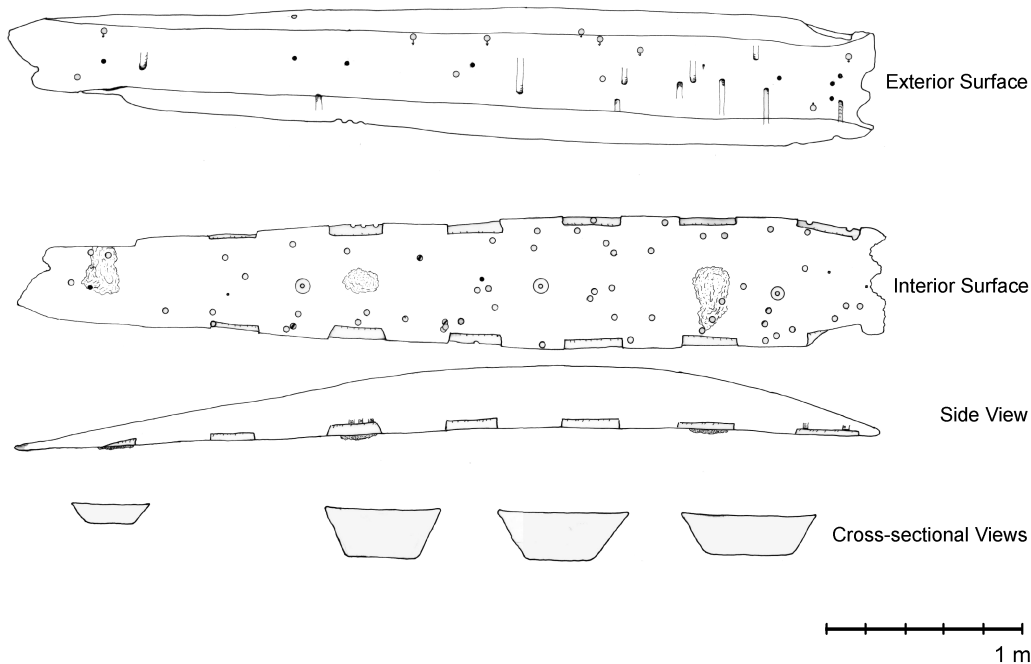


FIGURE 5-11.
Rising deadwood, Angra
C shipwreck. Illustration
by Erik Phaneuf.

deadwood with iron bolts. The first seven frames from the bow were seated in notches in the rising deadwood. This substantial timber measures 4.75 m in length and 75 cm in width and had a maximum thickness of 37 cm (fig. 5-11).⁴⁸

The spaces between the ends of the floors were filled with the lower ends of the futtocks, forming a solid band of timber at the bilges. The average preserved length of the futtocks on both port and starboard is 1.32 m. The molded and sided dimensions of the futtocks differ between the two sides of the ship. Most futtocks on the port side were sided between 17 cm and 34 cm and molded 24 cm. On the starboard side, the sided dimension varies between 21 cm and 31 cm, and the molded dimension is 22 cm.⁴⁹

Most floors and futtocks, like those of *Batavia* and Scheurrak SO1, are not fastened to each other but to the hull planking with wooden treenails. Two floor timbers, however, were joined to the futtocks with two lateral treenails, in addition to being securely locked with dovetail joints on the side of the timbers (floor 4 from the stern and 12 from the bow; figs. 5-12 and 5-13). Frame 12 had a double dovetail joint: the dovetail mortises were cut from the forward side of the floor timber, and the fixed dovetail tenons from the side of the futtock. The fixed dovetail tenon of frame 4 was cut from the aft face of the floor timber.⁵⁰

All floors had a central limber hole and were notched on the top of one or both sides to receive the keelson (fig. 5-14). A small fragment of the keelson was found underneath the ship's hull remains and was preserved over a length of 2.4 m. It averaged 34 cm sided. The lower end of the keelson is notched to fit over the ship's floor timbers and fastened to the floors with wooden treenails and iron nails. Its four preserved notches fit over frames 13–16 (counted from the vessel's stern).⁵¹

The ceiling consisted of one row of short removable ceiling or limber boards on either side of the keelson. This row of limber boards was followed on either side by two strakes

FIGURE 5-12.
Pre-assembled frame, floor
12 from the stern, Angra C
shipwreck. Illustration by Erik
Phaneuf.

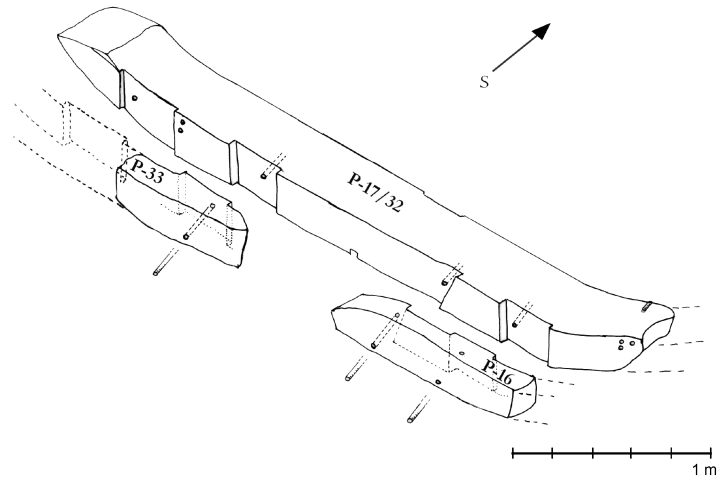


FIGURE 5-13.
Pre-assembled frame, floor
4 from the bow, Angra C
shipwreck. Illustration by Erik
Phaneuf.

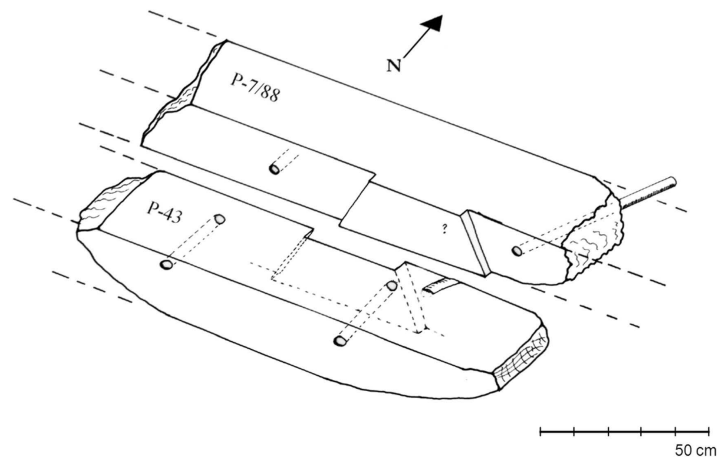
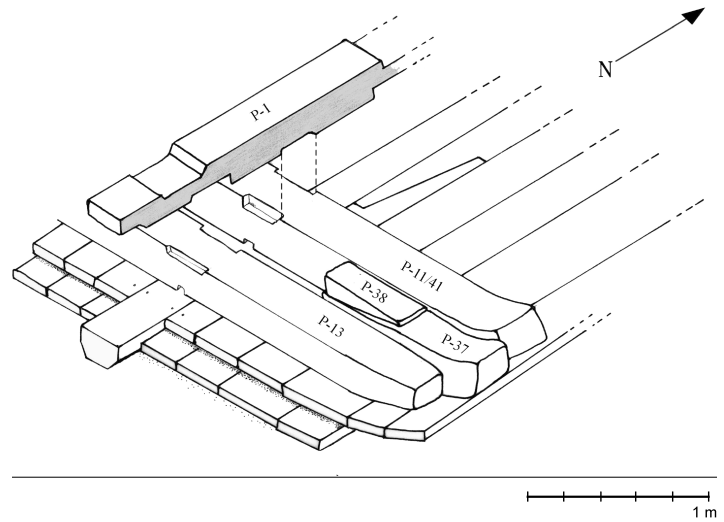


FIGURE 5-14.
Reconstruction of keel-floor-
keelson assembly, Angra C
shipwreck. Illustration by Erik
Phaneuf.



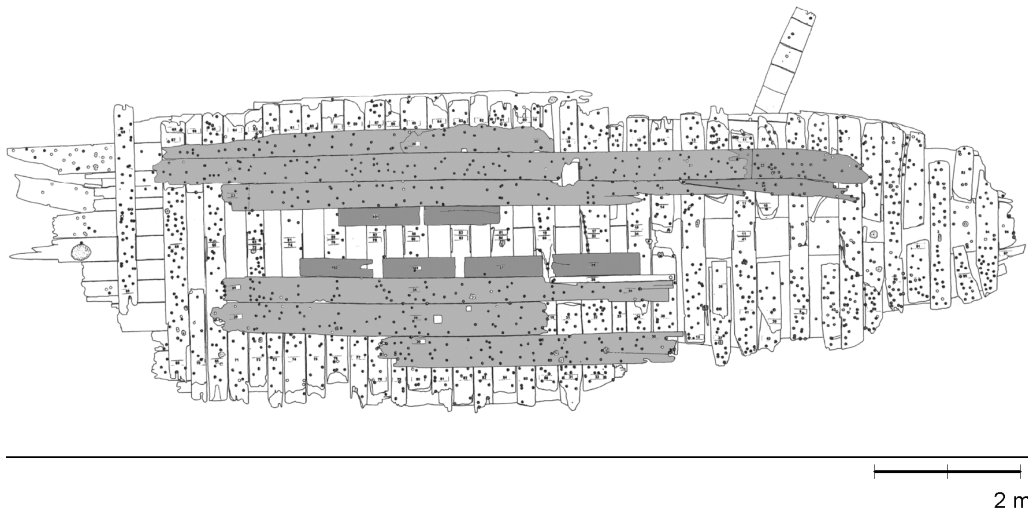


FIGURE 5-15.
Ceiling planking and
bilge stringers, Angra C
shipwreck. Illustration
by Erik Phaneuf.

of ceiling planking and a bilge stringer. The two strakes of ceiling planking were fastened to the frames with wooden treenails and iron nails (fig. 5-15). The ceiling has the same thickness as the hull planking (averaging 7 cm) and varies from 32 to 45 cm in width. The starboard stringer has a maximum preserved length of 4.4 m, is 45 cm in width, and is 12 cm in thickness. The port stringer and the first fixed ceiling strake indicate that the extremities of the ceiling planking were joined together with diagonal scarfs, whereas the planking of the second permanent ceiling strakes shows the use of a butt joint.⁵²

The absence of pine sheathing on the ship's exterior indicates that it was not destined to sail in tropical waters, but, like the Scheurrak SO1, was more likely a large oceangoing merchantman used for the intra-European trade.

DUTCH EAST INDIAMAN NASSAU (1606)

The VOC ship *Nassau* was one of the 11 ships of a squadron, renowned nowadays as the so-called Malacca Fleet (see fig. 4-6, top right). On 12 May 1605, seven ships of this squadron, all equipped by the VOC Chamber of Amsterdam, set sail from Texel: *Oranje* (700 tons), *Middelburg* (600 tons), *Mauritius* (700 tons), *Zwarte Leeuw* (600 tons), *Witte Leeuw* (540 tons), *Grote Zon* (540 tons), and *Nassau* (320 tons). Twelve days later two ships of the Chamber of Zeeland, *Amsterdam* (700 tons) and *Kleine Zon* (220 tons), followed from the Dutch port of Wielingen.⁵³ These ships sailed to the Indies under command of Admiral Cornelis Matelief de Jonge, who had secret instructions to besiege the Portuguese stronghold of Malacca.⁵⁴ Two stragglers, *Erasmus* (540 tons) from the Chamber of Rotterdam and the *Geünieerde Provinciën* (400 tons) from the Chamber of Delft, left much later on 30 May and finally reinforced the fleet at Malacca more than a year later on 14 July 1606.⁵⁵ The Dutch offensive was declared when the Dutch burned four Portuguese ships on 30 April 1606. The subsequent period was characterized by a series of bloody events, in which the Dutch were supported by hundreds of galleys and *fustas* of their ally, the Sultan of Johore, who also provided the Dutch with a safe haven in the Johore River to which they could retire in their ships from the battle. The Portuguese were assisted by an armada under command of the viceroy of Goa.⁵⁶ The Dutch did manage to enfeeble the Portuguese by burning three large galleons, *San Salvador* (900 tons), *San*

Nicolas (800 tons), *Don Henrique de Norinha* (900 tons), and the ship *Santa Cruz* (600 tons) and left hundreds of Portuguese men slain or wounded.⁵⁷ According to the daily register kept by Matelief's fleet 18 Portuguese ships were lost to Dutch fire or destroyed by the Portuguese crew to keep their ships out of Dutch hands.⁵⁸ Nevertheless, Admiral Matelief and his men gave up on 16 December 1606, without having achieved their aim.⁵⁹ The VOC did not finally take Malacca until 1641.⁶⁰

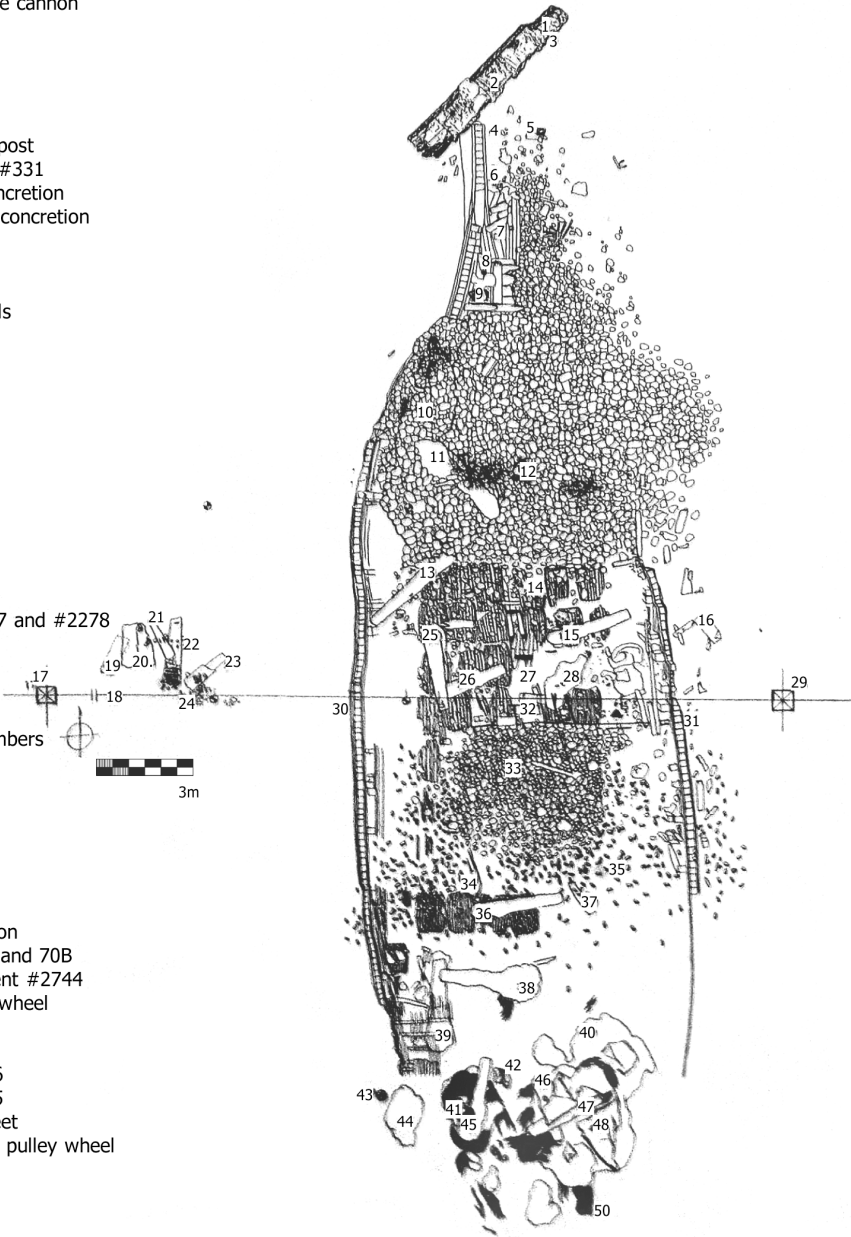
During the attempted siege of Malacca, *Middelburg* and *Nassau* were lost in the Strait of Malacca on 18 August during a naval battle.⁶¹ The latter was one of two ships destined to stay in Asia to be decommissioned; the other was *Kleine Zon*. When the two ships were prepared two years earlier for their last long journey to the Indies, the VOC instructions specifically emphasized that nails and sheathing boards would be sent from Holland to the Indies for their maintenance.⁶² *Kleine Zon* was indeed resheathed in Bantam, a port city near the western end of Java in Indonesia, after it had started leaking in the fall of 1608. Its pine sheathing was worn out after three years, but its oak planking was still in good condition and worm-free.⁶³ *Kleine Zon* was eventually decommissioned and broken up in the Banda Islands in 1611.⁶⁴

Nassau and *Kleine Zon* probably had an extensive working life before they joined Matelief's fleet, as they were both to retire in Asia. *Nassau*'s history can, however, be traced back to only one, possibly two, previous journeys. It sailed to the Indies with the large fleet under command of Wybrand van Warwijck from 1602 to 1604.⁶⁵ It might also have sailed to the Indies for the Nieuwe Brabantse Company with Pieter Both and Paulus van Caerden in 1599.⁶⁶ This journey was undertaken with four ships, *Nederland*, *Verenigde Landen*, *Nassau*, and *Hof van Holland* (360 tons); was organized by the states of Zeeland; and sailed simultaneously with the fourth Dutch journey to the Indies.⁶⁷ This fleet was intended to trade in China but never did. Instead, the four ships showed up in Bantam in 1600.⁶⁸ It is uncertain whether the ship that sailed on this voyage is the same *Nassau*; it may have been another ship with the same name. No indication of the ship's tonnage is given for this particular journey. The *Nassau* that went down in the Strait of Malacca in 1606 is likely to have been an older ship, as it was to retire in the Indies. Matelief mentions in his account that the ship's stern and gallery caught fire after a fierce naval encounter with two enemy ships, *Conceicao* and *Santa Cruz*, on 18 August 1606.⁶⁹

In 1607, Jacques L'Hermite de Jonge aboard *Erasmus* wrote a lengthy letter to his father in which he shared his thoughts about the modifications made by the Chamber of Amsterdam to its ships, including *Nassau*, *Mauritius*, *Middelburg*, and *Witte Leeuw*. All were purposely fitted for this journey *without* a forecastle and quarterdeck aft of their mainmast.⁷⁰ According to L'Hermite, the large ship *Middelburg* may not have been burned if it had had both forecastle and quarterdeck, providing the crew with options for fighting the fire and saving the ship from Portuguese hands. It would have given shelter and protection from the armament on a level higher than the gun deck. Instead, the men had no other choice but to stay belowdecks to protect themselves.⁷¹ This was essentially the same complaint Richard Hawkins had with the low-built English galleons in fighting tall Spanish ships around 1600.⁷² L'Hermite elaborates on how the late Adriaen Fransz had purposely removed the forecastle and quarterdeck from *Erasmus* on the ship's previous journey, which cost several lives when putting out a fire at its beakhead and bowsprit during a conflict with a Portuguese carrack.⁷³ For this particular journey, the ship was purposely fitted with a new forecastle and quarterdeck to prevent a repeat of the incident.

Legend

1. Muzzle of bronze cannon
2. Pottery #4383
3. Rudder
4. Sternpost
5. Wood pieces
6. Lead sheets
7. Timber of sternpost
8. Lead sheet roll #331
9. Musket shot concretion
10. Ballast stones concretion
11. Cannon #334
12. Molten metals
13. Cannon #8
14. Wooden barrels
15. Cannon #7
16. Lead sheet
17. West box
18. Baseline
19. Cannon #5
20. Cannon #4
21. Cannon #2
22. Cannon #1
23. Cannon #3
24. Bricks
25. Cannon #6
26. Cannon #14
27. Anchors #2277 and #2278
28. Concretion
29. East box
30. Starboard hull
31. Port hull
32. Dove-tailed timbers
33. Ballast stones
34. Wood pieces
35. Bricks
36. Cannon #76
37. Wood pieces
38. Cannon #42
39. Cannon #45
40. Large concretion
41. Cannon #70A and 70B
42. Bronze fragment #2744
43. Bronze pulley wheel
44. Concretion
45. Cannon #72
46. Cannon #2746
47. Cannon #2645
48. Large lead sheet
49. Broken bronze pulley wheel
50. Ropes

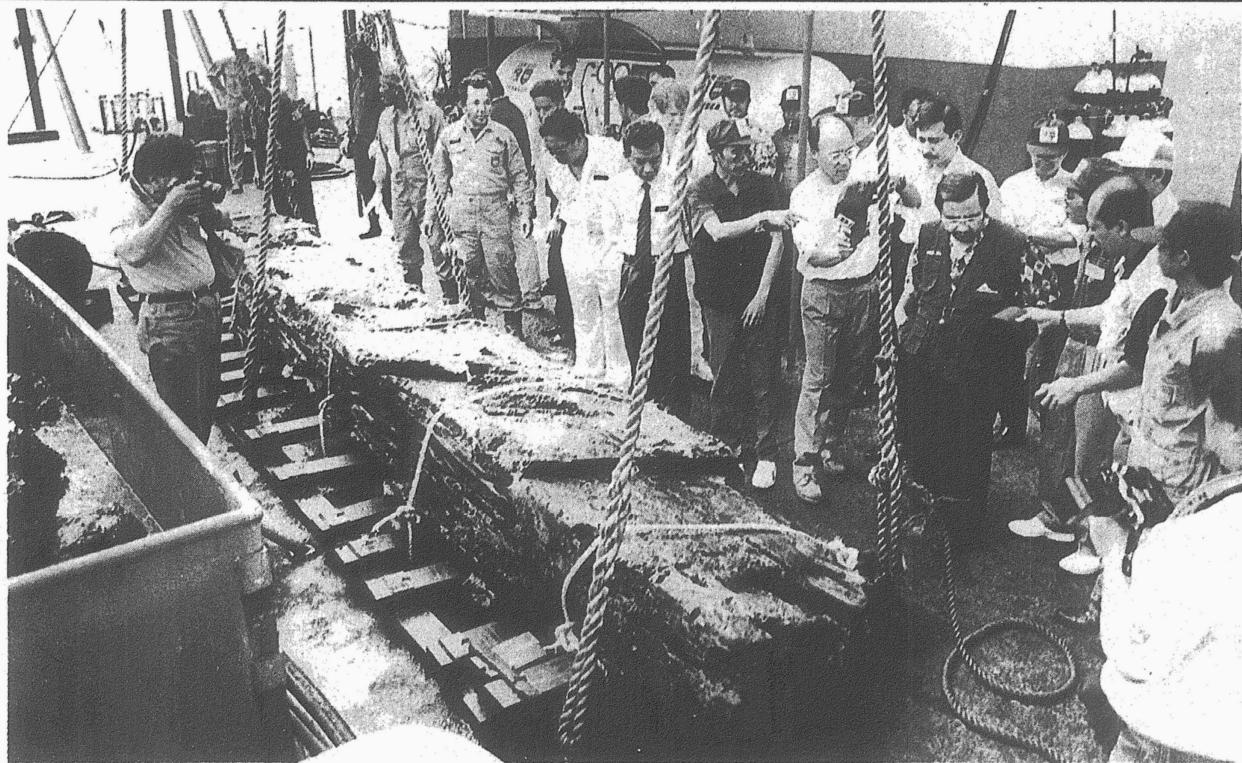
**FIGURE 5-16.**

Site plan of *Nassau* shipwreck. Department of Museums Malaysia.

The shipwrecks of *Middelburg* and *Nassau* were found in 1993 by a local marine salvage and engineering company, Transea Sdn Bhd. They are the oldest VOC shipwrecks discovered on the seabed. While *Middelburg* remains untouched, *Nassau* was salvaged two years after its discovery with permission of the Malaysian government under the direction of Mensun Bound. The ship's hull lies with a list to port and is well preserved to above the turn of the bilge (fig. 5-16). Unfortunately, "no attempt was made to reveal and study the lower timberwork [of the ship's hull]." This was due to lack of time, poor visibility, and reluctance to expose any more of the hull than necessary to biological attack. More detrimental, the exposed hull structure has not been recorded or studied in detail. It is

NEW SUNDAY TIMES, DECEMBER 3, 1995

NATIONAL



FOUR-CENTURY-OLD FIND ... Mohamed Isa being briefed by Ong (on Mohamed Isa's right) on the progress of excavation work yesterday. — NST picture by Leong Weng Onn.

No decision on salvaging Dutch galleon

PORT DICKSON, Sat. — The decision to bring up the wreckage of the *Nassau*, a 400-year-old Dutch galleon which sank nearly four centuries ago at Bambek Shoel, eight nautical miles off Port Dickson, will only be made after the final report on the matter has been studied.

Muzium Negara Antiquity Department acting director Paiman Keromo said the decision would only be made next April once the final report on the archaeo-

logical excavation work was completed.

The vessel which sank in August 1604 is being explored by Transea (M) Sdn Bhd, a local salvage company, in collaboration with Britain's Oxford University and Universiti Kebangsaan Malaysia.

They are being assisted by the national museum's Antiquity Department.

Paiman said this after Menteri Besar Tan Sri Mohamad Isa Abdul Samad's

visit to the excavation site today.

Mohamad Isa was briefed on the progress of work by Transea director Ong Soo Hin and Oxford University director of marine archaeology Mensun Bound, who is leading the excavation.

"We have not decided whether to bring up the wreckage. A decision will only be made next April.

"We must make a proper assessment whether it is all right to bring up the wreck-

age as it may not be practical. The wreckage is now four centuries old. We must be really sure that we can retain its originality.

"As for now, we will collect all data on the artifacts to complete our reports," he said at the excavation site.

Over 3,000 items have been brought up since excavation work started in mid-August.

They include 16 ancient cannons, porcelain ware, coins, musket shots and other

items used in a sea battle with the Portuguese.

The excavation work which cost RM3.33 million is being funded by the Government.

Historical records show that the *Nassau*, together with another vessel *Middleburg*, sank there when a Dutch fleet of 11 ships went into battle with a Portuguese armada of 70 vessels.

Two Portuguese galleons were lost in the battle along with about 600 men.

FIGURE 5-17. *Nassau's* rudder raised from the seabed.

known that the ship's hull had a double layer of hull planking equal in thickness (roughly 6 to 8 cm per strake). The same thickness is given for its ceiling planking. Bound elaborates that "most if not all, of the exterior hull below waterline was lead sheathed and at the stern, around the post and below the tuck, it had been partially coppered." The lead sheathing observed on the outside of the outer layer of hull planking is likely a layer of lead in between the hull planking and pine sheathing.⁷⁴

Nassau's well-preserved rudder was raised during the ship's salvage in 1995 (fig. 5-17). It is unknown what has happened to this timber since its removal from the seabed.

No archaeological research has yet been conducted or published on both *Nassau* and *Middelburg*, which is unfortunate since their hulls could provide much detailed information on early seventeenth-century shipbuilding.

DUTCH EAST INDIAMAN *MAURITIUS* (1609)

The Dutch East Indiaman *Mauritius* first sailed to the Indies for the Amsterdam Chamber of the VOC in June 1602 as one of the 14 ships of Wybrand van Warwijck's fleet.⁷⁵ It was an East Indiaman with a length between 140 and 160 Amsterdam ft (40 and 45 m) and a capacity of about 700 tons.⁷⁶ The VOC subsequently purchased the ship upon its return from the Indies for 23,500 guilders in the autumn of 1604. At the same time, the yacht *Witte Leeuw* was purchased for 55,000 guilders. This difference is surprising, since *Witte Leeuw* is a smaller vessel, at only 540 tons. Moreover, it is specifically mentioned that *Witte Leeuw* "had only been to the Indies once before."⁷⁷ The low price for *Mauritius* suggests that the vessel was already quite old at this time.⁷⁸ If this is true, the ship cannot have been built in 1601 or 1602 on an Amsterdam shipyard as published by L'Hour, Long, and Rieth.⁷⁹ It is likely to have sailed to the Indies before it was accessioned into VOC service in 1602, and *Mauritius* may even have been the same ship that had sailed to the Indies three times before since 1595 (see fig. 4-4). The early *Mauritius* was listed as a 460-ton ship built in 1594, but it may have been rebuilt and enlarged by the VOC in 1602 as was done more often with newly acquired ships.⁸⁰

A contemporary manuscript drawing of *Mauritius* details the ship with other VOC ships of the Malacca Fleet. This fleet, under the command of Cornelis Matelief de Jonge, encountered the Portuguese in the Battle of Cape Rachado in 1606 (see fig. 4-6). On 27 December 1607, *Mauritius* set sail from Bantam to Patani to take over the cargo of a Portuguese prize ship.⁸¹ For its homebound voyage, it was loaded with 120 tons of pepper, sugar, and gum-benzoin. A clerk who sailed with *Mauritius* recorded its last voyage, and from his account we know that it ran aground and broke to pieces near Cape Lopez on the West African coast on 19 March 1609. Not until 8 September 1609 did news reach Amsterdam that some survivors of *Mauritius* had just arrived in Texel. The wreck of *Mauritius* was discovered in 1985 by the French oil company Elf-Gabon during bathymetric prospecting. Elf-Gabon subsequently sponsored two excavation campaigns in 1986, supervised by the Direction des Recherches Archéologiques Sous-Marines (DRASM).⁸²

Of the hull structure only a small section, including 24 floors and 22 futtocks, is preserved, which measures 13 to 15 m in length and 4 to 6 m in width (fig. 5-18).⁸³ The floors are consistently 30 cm molded at the keel. The molded dimension tapers to 25 cm about 3 m away from the keel. Their average sided dimension varies from 18 to 34 cm. The futtocks are 25 cm molded and 15 to 20 cm sided.⁸⁴ The oak floors and futtocks, like those of *Batavia* and the Scheurrak SO1, are not fastened to each other but treenailed to the hull planking. The hull planking consists of two layers of oak planks that average 14 cm in total thickness (7 cm per strake). The two layers making up the garboard strake are each 9 cm thick, and those of the second strake are 8 cm. As in *Batavia* and the Barents yacht, the outer layer of planking is fastened to the inner layer with iron spikes.

In addition to the double layer of hull planking, a thin layer of pine sheathing (*Pinus sylvestris*, 3 cm in thickness) was fastened to the hull with iron nails. Furthermore, a thin layer of lead sheathing was placed between the two layers of hull planking and between the outer hull planking and pine covering.⁸⁵

FIGURE 5-18.
Site plan of shipwreck
of Dutch East Indiaman
Mauritius. Illustration
by Luc Long and Michel
Rival, in L'Hour, Long,
and Rieth, *Le Mauritius*,
198–99. © CASTERMAN
S.A.

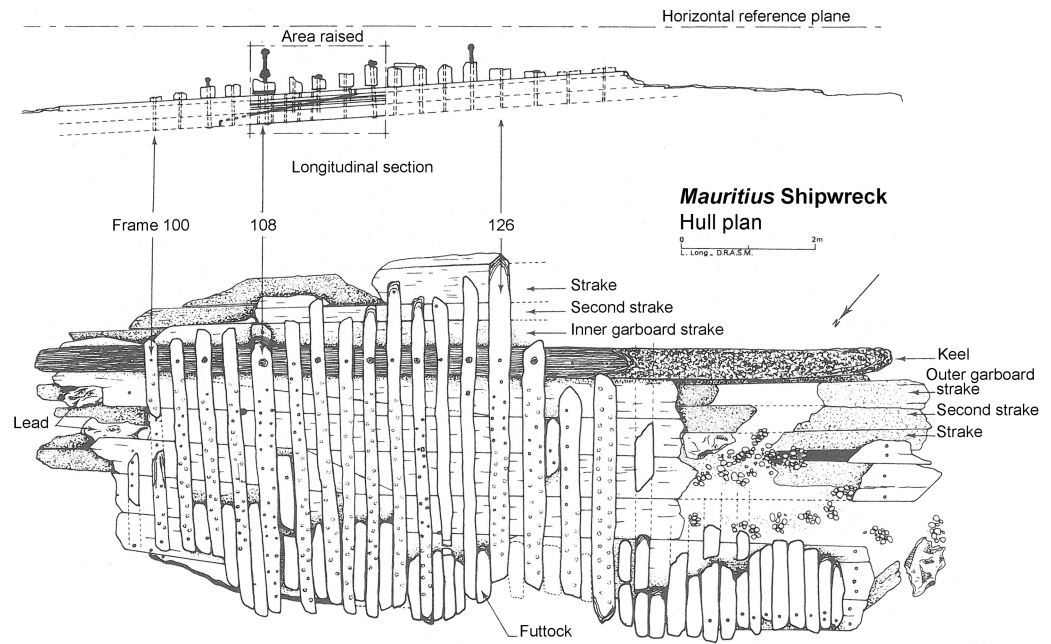
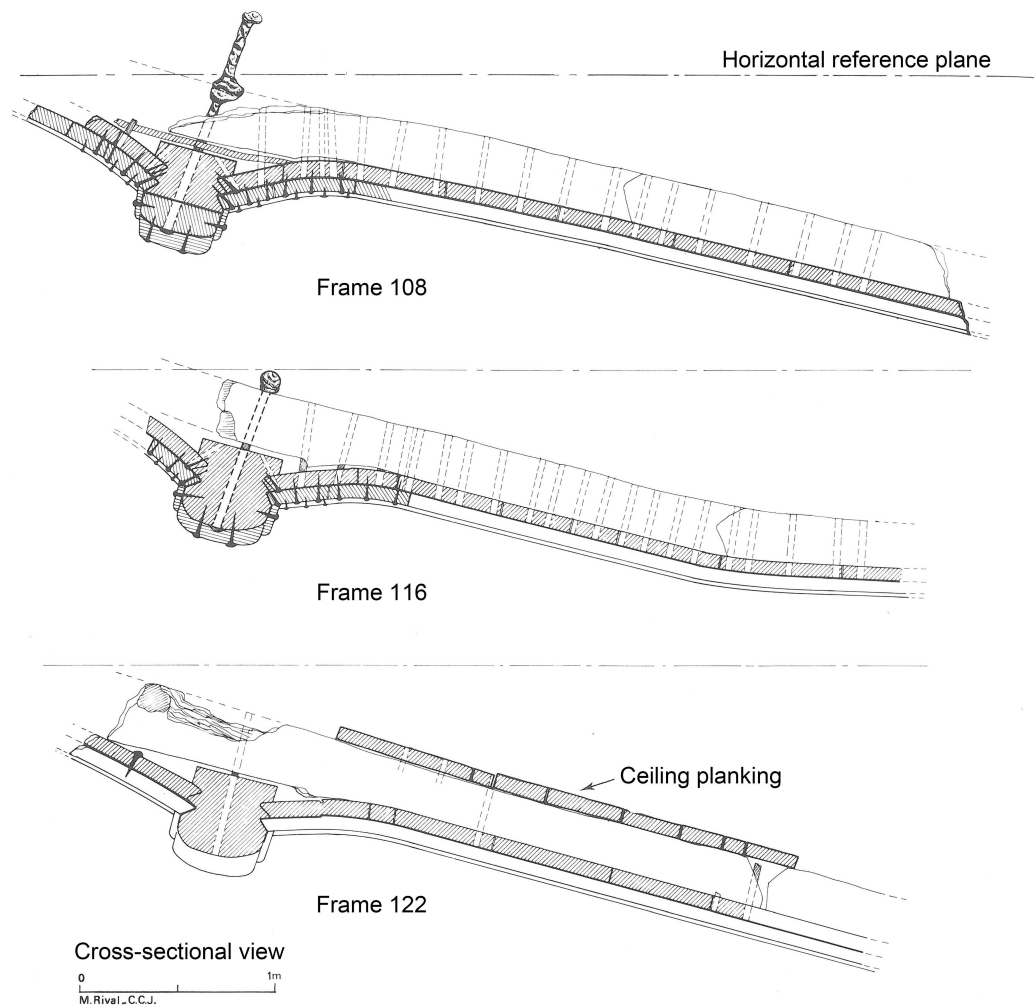


FIGURE 5-19.
Cross sections of
Mauritius's hull at
frames 108, 116, and 122.
Illustration by Michel
Rival, in L'Hour, Long,
and Rieth, *Le Mauritius*,
200. © CASTERMAN S.A.



The oak keel, consisting of three pieces of timber scarfed together, has a molded dimension of 42 to 43 cm and a sided dimension of 39 to 42 cm. It has a double rabbet, as do the Scheurrak SO1 and Christianshavn B&W 2, to accommodate the two layers of oak hull planking.⁸⁶ The ship's planking is sheathed with a layer of pine below its waterline.⁸⁷ The angle of the upper rabbet is about 60 degrees, and the lower one, 75 degrees (fig. 5-19). The garboard strakes of Dutch ships are usually angled, as illustrated by the Scheurrak SO1 (1590s) and Scheurrak T24 (post-1655).⁸⁸ According to Witsen, this is important, as water can be pumped out more easily when the garboard strakes have some angle (see fig. 2-10a, b).⁸⁹

YACHT VERGULDE DRAAK (1656)

The shipwreck of *Vergulde Draak* was the first Dutch East Indiaman to be discovered in Australian waters and the first major shipwreck selected for archaeological excavation by the Western Australian Museum. Excavations began in 1972 under the direction of Jeremy Green. The wreck site was revisited and the excavation resumed in 1981 and 1983.⁹⁰

Vergulde Draak sank on its second voyage to the Indies when it ran onto an offshore reef, 120 km north of Perth, along the Western Australian coast. The VOC Chamber of Amsterdam bought the 260-ton ship in 1653.⁹¹ The acquisition of the ship was approved on 24 January 1653, after it was inspected by two representatives of the Chamber named Roch and Haes. It was probably not new, as it is specifically mentioned that the *newly bought* ship was at anchor in Zaandam, whereas the VOC archives generally refer to a *newly built* ship if it had been just constructed. Moreover, the low price, 28,250 guilders, suggests that the ship had been extensively used. The ship, named *Vergulde Draak* on 10 March 1653, was 137 Amsterdam ft (38.78 m) in length, 32 Amsterdam ft (9.05 m) in beam, and 13.5 Amsterdam ft (3.82 m) in height (plus 7 Amsterdam ft, 1.98 m, above the upper deck).⁹²

Unfortunately, no intact structure of *Vergulde Draak*'s hull was found during any of the three excavation seasons.⁹³ Fragmentary pieces of the ship's timbers were recovered and were listed in the 1977 publication as wooden objects recovered from the shipwreck site.⁹⁴ After the 1972 excavation, only a frame, some hull planking, and a knee could be identified among the excavated hull remains.⁹⁵ Additional fragments of ship timber were raised during the later excavation seasons. Most of these timbers were raised in the areas

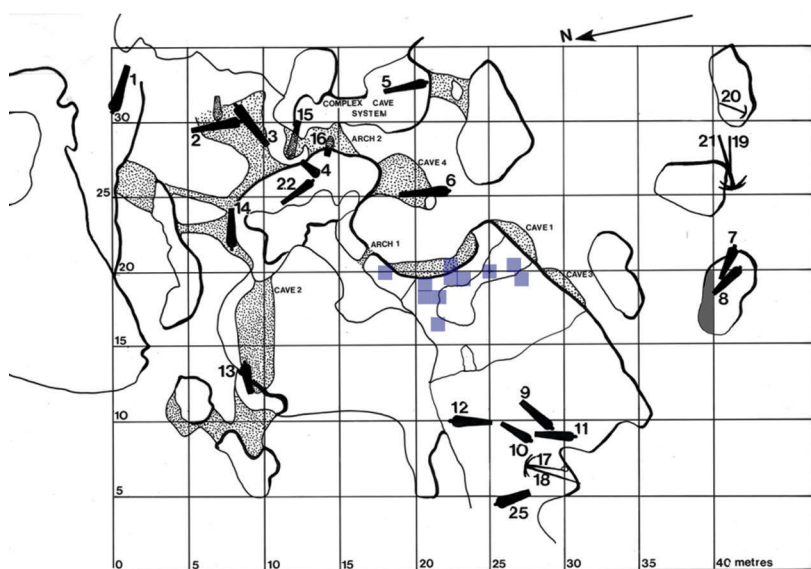


FIGURE 5-20.
Vergulde Draak
shipwreck site,
showing location
of the ship's frag-
mentary timbers in
purple. Plan after
J. Cowen, G. Brenzi,
R. Sonnerman, and
W. Anderson, 1966.

FIGURE 5-21.
Vergulde Draak's timbers in
 conservation desalination
 tank after shipwreck's
 first excavation, May 1972.
 Photograph by Patrick Baker,
 Western Australian Museum.



of the overhanging rocks near Cave 1 and Cave 3 on the site (fig. 5-20).⁹⁶ *Vergulde Draak's* preserved hull remains were so sparse and disarticulated that they were not recorded in situ, and initially no attempts were made to study and reconstruct them. Nonetheless, the numerous fragments raised during all three excavation seasons have been conserved (fig. 5-21).

In June 2007, an intensive study of *Vergulde Draak's* hull remains was commenced under my direction. To date, 141 diagnostic registered lots of *Vergulde Draak* hull timber have been cleaned, cataloged, and, if representative, photographed and drawn (fig. 5-22).⁹⁷ These lots include 482 fragments of the ship's hull timbers, mainly comprising hull planking, frames, sacrificial planking or sheathing, and treenails (figs. 5-23 through 5-26). The timbers, however, are poorly preserved, and the wood is more worm-riddled, degraded, warped, and longitudinally cracked than *Batavia's* timbers.

Eleven timbers and wooden fasteners have been sampled and analyzed for wood identification. The results have shown that at least two different genera of wood were used in the ship's construction; all structural timbers sampled were made of oak (*Quercus* sp.). The sacrificial planking or sheathing of *Vergulde Draak's* hull was made of pine, most likely *Pinus sylvestris* (table 5-2).⁹⁸

None of the fragments of hull planking are preserved over their entire length or width, and the maximum preserved length is 91 cm and width 45 cm. The average thickness of the hull planking is 9.0 cm, and one fragment of a wale is 14.8 cm thick (GT 6012).⁹⁹ This planking thickness is consistent with the shipbuilding charter for merchant yachts dating to 24 May 1653, which prescribed a thickness of 3.5 Amsterdam thumbs (9 cm) up to the lowest wale (appendix A).



FIGURE 5-22. The author (*left*) and conservator Maggie Myers (*right*) cataloging and cleaning timbers from *Vergulde Draak* in the conservation wet laboratory, Western Australian Museum—Shipwreck Galleries, Fremantle, August 2007. Photograph by Patrick Baker, Western Australian Museum.

FIGURE 5-23.
Fragment of frame
wood from VOC ship
Vergulde Draak, GT
1386 P. Photograph by
Patrick Baker, Western
Australian Museum.



Four fragments of hull planking show that they were joined to other planks with flat scarfs.¹⁰⁰ The ends of these flat scarfs were nailed down with iron fasteners, square in section, to strengthen the joint between scarf ends.¹⁰¹ These nail holes have an average cross section of 8 mm, and the diameter of one preserved rounded nail head impression is 2.6 cm.

The better-preserved fragments of *Vergulde Draak*'s hull planking all have closely spaced nail holes on their exterior surfaces, 4 to 7 cm apart, in a quincunx pattern. The nail holes were left behind by iron filling nails that would have fastened the ship's pine sheathing to the hull planking; the nails had square shanks with an average cross section of 4 to 5 mm (see fig. 5-26).

Interestingly, the hull planking shows no sign of iron nails being used to fasten the outer layer to the inner layer of planking (as seen on the Barents yacht, *Batavia*, *Mauritius*, and Christianshavn B&W 2). Instead, treenails were the primary fasteners of the hull planking, as seen on the inner layers of hull planking of all these ships (and the outer layer of hull planking of the Scheurrak SO1 and Angra C).

The average diameter of the treenails found in the *Vergulde Draak*'s hull planking, frame fragments, and individual treenails raised from the shipwreck site is 3.2 cm. These treenails are not perfectly circular as a result of their manufacture; they were fashioned from oak and not turned on a lathe. Archaeological evidence has demonstrated that tree-nails split out of oak were used in the construction of many northwestern European ships



FIGURE 5-24.
Fragment of pine
sheathing from VOC
ship *Vergulde Draak*, GT
1386 L. Photographs by
Patrick Baker, Western
Australian Museum.

dating to the postmedieval period. They include seventeenth- and eighteenth-century ships such as *Mauritius*, *Batavia*, Christianshavn B&W 2, *Angra C*, and *Nieuw Rhoon* and later ships such as the nineteenth-century, English-built merchantman found in the Netherlands (SL4) that was used in the coal trade with Rotterdam.¹⁰²

No examples of complete treenails from *Vergulde Draak* have been found that are preserved over their entire length. The longest preserved treenail, not seated in a timber, is 20.5 cm and is pegged with a square peg on its intact end (fig. 5-27, GT 6030 B). To date, 22 pegged treenails and 3 treenail pegs have been identified, and, if still seated in hull planking or have filling nail holes preserved, they indicate that their pegs were driven into the treenails on the planking's exterior surface (see figs. 5-26 and 5-28). The pegs have an average width of 2 cm at their top surface; they taper to a point over an average length of 4.6 cm (maximum 1.5 cm).

Several wooden nail plugs were found on the interior and exterior faces of poorly preserved fragments of oak hull planking that all show clear filling nail holes on their

FIGURE 5-25.
Frame timber from VOC
ship *Vergulde Draak*, GT
6164. Photographs by
Patrick Baker, Western
Australian Museum.



exterior faces (fig. 5-29). One oak nail plug was removed from hull plank GT 6167; it is preserved over a length of 2 cm and has a maximum cross section of 6 mm (fig. 5-30). Generally, *Vergulde Draak*'s nail plugs vary in length between 2 and 3 cm and have an average width of 8 mm at their top surface.

In addition, not a single fragment of hull planking from the ship's bottom has been observed *with* nail plugs but *without* filling nail holes on its exterior face. In fact, all fragments of hull planking studied have holes from filling nails on their exterior surface. This is important because it indicates that *Vergulde Draak* had no inner layer of hull planking and, thus, was not assembled with two layers of oak hull planking. The absence of fragments from an inner layer of hull planking and the presence of nail plugs on the interior and exterior faces of hull planking sheathed with pine (as indicated by the filling nails on

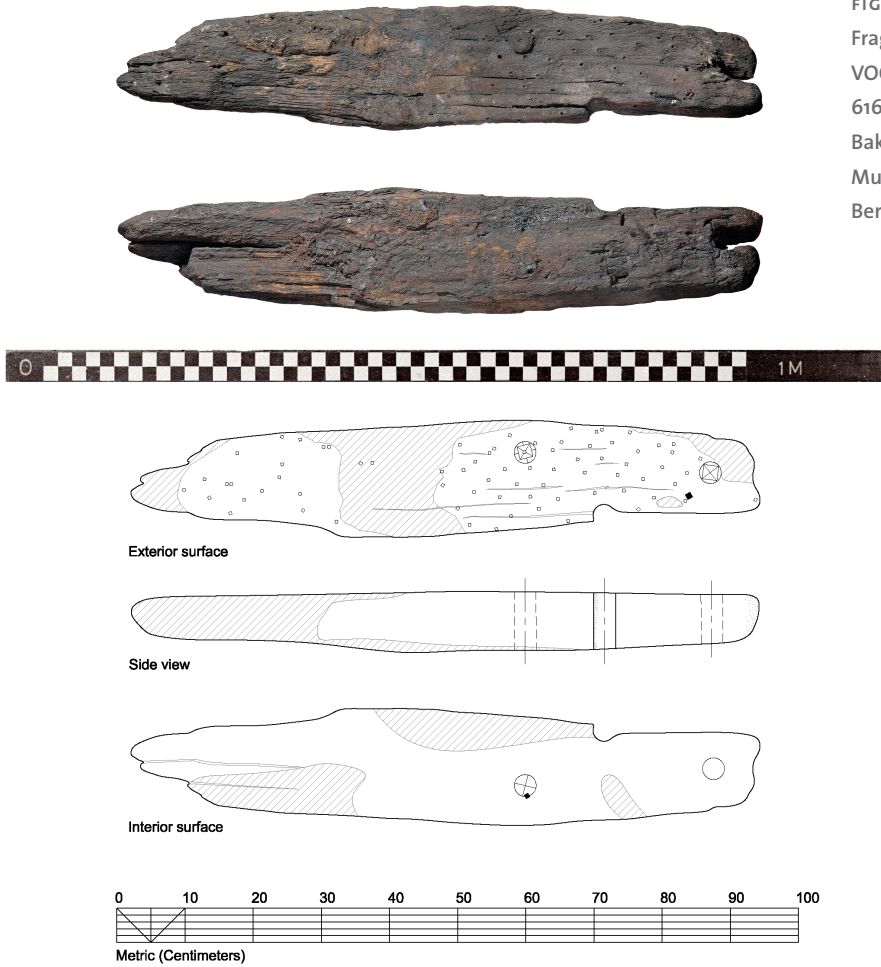


FIGURE 5-26.

Fragment of hull plank from VOC ship *Vergulde Draak*, GT 6166. Photographs by Patrick Baker, Western Australian Museum. Illustration by Jessica Berry and author.

TABLE 5-2. Identification of wood used in *Vergulde Draak*'s hull timbers

Catalog number	Source of sample	Wood species
GT 61	Sheathing (sacrificial planking)	<i>Pinus sylvestris</i>
GT 98	Sheathing (sacrificial planking)	<i>Pinus</i> sp.
GT 1386 D	Treenail from frame	<i>Quercus petraea</i>
GT 1386 L	Sheathing (sacrificial planking)	<i>P. sylvestris</i>
GT 1386 M	Hull planking	<i>Q. robur</i>
GT 1386 N	Hull planking	<i>Q. robur</i>
GT 1386 P	Treenail from frame	<i>Q. petraea</i>
GT 1386 P	Frame	<i>Q. petraea</i>
GT 6020	Sheathing (sacrificial planking)	<i>P. sylvestris</i>
GT 6095	Treenail from hull or ceiling planking	<i>Q. robur</i>
GT 6166	Hull planking	<i>Q. robur</i>
GT 6167	Nail plug from hull planking	<i>Quercus</i> sp.

FIGURE 5-27.
Pegged treenails from
VOC ship *Vergulde Draak*.
Illustration by author.

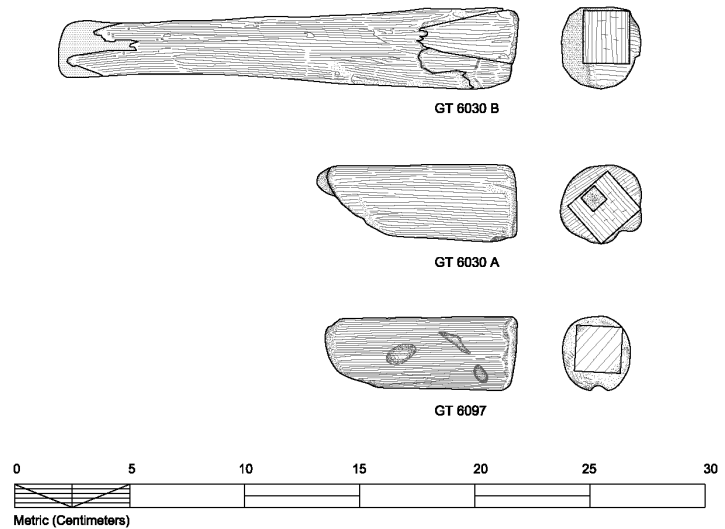
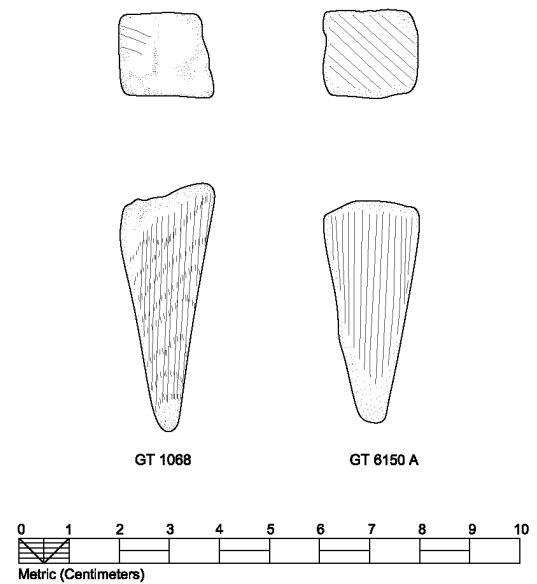


FIGURE 5-28.
Treenail pegs from VOC ship *Vergulde Draak*.
Illustration by author.



its exterior) suggest that the ship was constructed using a bottom-based method with one single layer of oak hull planking. Furthermore, the transverse nails used to fasten the ends of the flat scarfs from the ship's hull planking also support a bottom-based construction method. The scarf ends would have been nailed to the nearest frame timber if frames had been standing and not to a corresponding scarf end in the hull planking.

Treenails were used below the waterline for VOC ships throughout the seventeenth and eighteenth centuries regardless of whether they were built using a bottom-based or frame-based method, as all ships discussed in this chapter exemplify for the seventeenth century. The hull remains of, for example, the late eighteenth-century VOC ship *Buitenzorg* (1760) also have provided evidence for the use of pegged treenails below its waterline, even though this ship was built using a frame-based method.¹⁰³ Even the meager hull remains of the VOC ship *Zuiddorp* (1712), which sank at the base of steep cliffs situated roughly halfway between Kalbarri and Shark Bay in Western Australia, include one



FIGURE 5-29.
Fragment of hull
planking of VOC ship
Vergulde Draak, GT 6142
P. Location of nail plugs
indicated by arrows.
Photographs by author.



10 cm

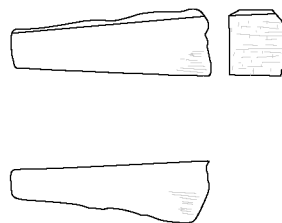
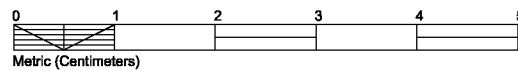


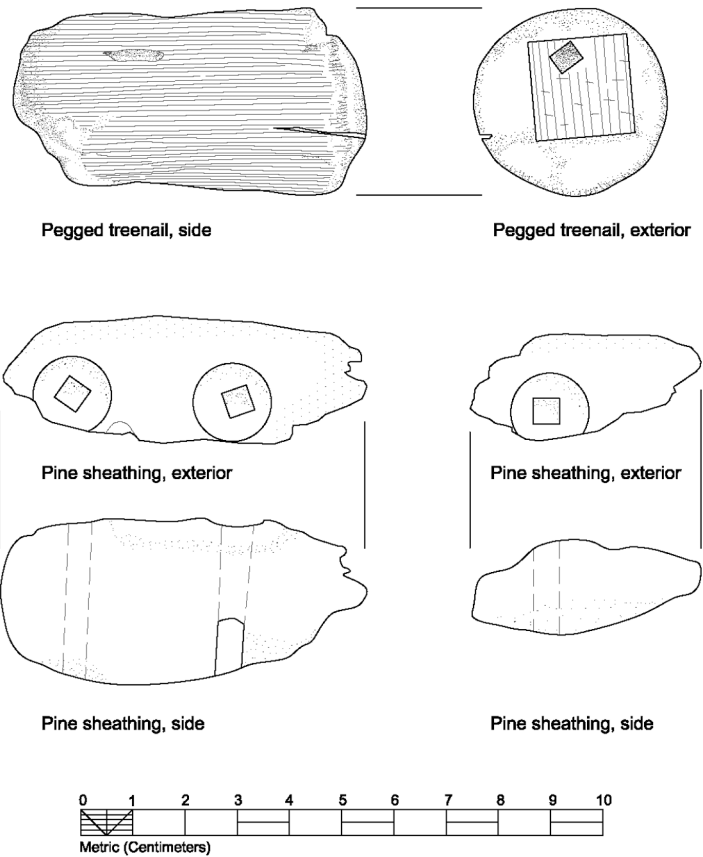
FIGURE 5-30.
Nail plug from VOC ship
Vergulde Draak, GT 6167.
Illustration by author.



Metric (Centimeters)

FIGURE 5-31.

Pegged treenail and two fragments of pine sheathing from VOC ship *Zuiddorp*, ZT 4022. Illustration by author.



pegged treenail and two fragments of pine sheathing (fig. 5-31). This pegged treenail still retains the nail hole of a filling nail, indicating that it was used to fasten the frames to the hull planking (or vice versa) and was pegged at the exterior surface of the hull planking. It also suggests that the ship was built with one layer of oak hull planking. Certainly, the presence or lack of treenails is not sufficient evidence for a specific construction method.

Fragments of the *Vergulde Draak* framing also confirm the use of treenails as the main fasteners to join the frames to the planking. To date, none of the frame remnants have provided evidence for lateral fastening or assembly, which suggests that the ship's floors and futtocks were not connected. Though evidence from the frames is sparse, their remnants do support a bottom-based method for *Vergulde Draak*'s construction.

Like *Vergulde Draak*'s planking, none of its frame timbers are preserved over their entire length or width, and the largest fragment has a maximum length of 1.44 m, a maximum sided dimension of 20.5 cm, and a molded dimension of 16.5 cm (GT 6164). Two treenails have been observed that are wedged with a small wedge (both 7 mm in thickness) on the interior surfaces of two frame timbers (GT 6171 and GT 6185).

Several blind treenails found on the interior surface of the hull planking and frames indicate that treenails were used to fasten the ceiling planking to the frames and hull planking (fig. 5-32).¹⁰⁴ Generally, these blind treenails seem to be slightly smaller in diameter than the ones used to fasten the frames to the hull planking, as they vary in diameter between 2.7 and 3.1 cm, with an average of 3 cm.

Five bolts or bolt holes have been preserved in *Vergulde Draak*'s hull planking and

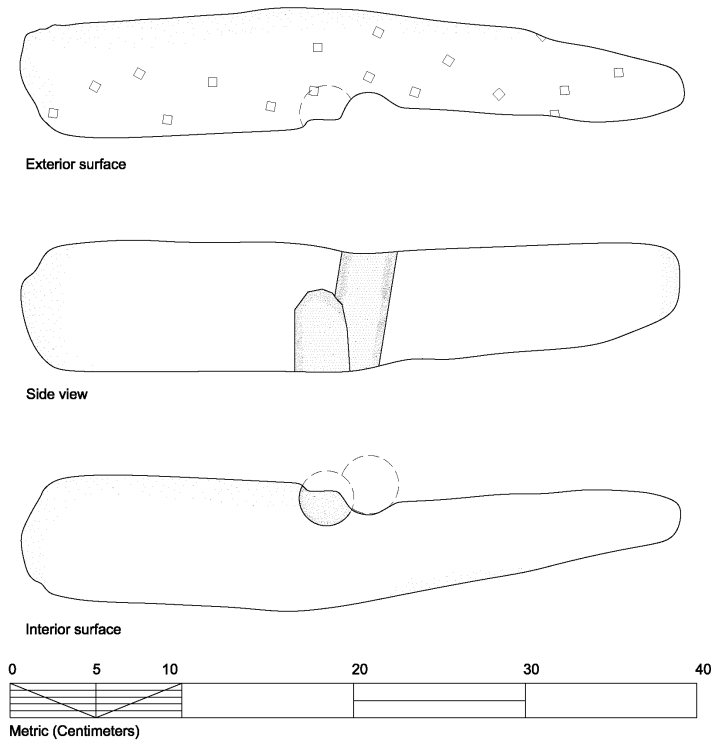


FIGURE 5-32.

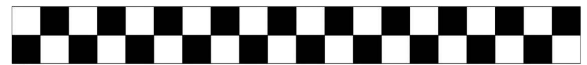
Fragment of hull plank from
VOC ship *Vergulde Draak*, GT
1386 C. Illustration by author.

frames that probably fastened the ship's riders to the ceiling planking, frames, and hull planking. These bolts have round shanks with an average diameter of 2.2 cm. Two bolt head impressions are preserved on the exterior surface of the ship's hull planking (diameter 3.6 cm).

As mentioned previously, *Vergulde Draak*'s pine sheathing was fastened to the ship's hull planking with iron filling nails, which had square shanks (average cross section 5 mm) and circular heads (their diameters vary between 1.3 and 1.8 cm, with an average of 1.5 cm). The average thickness of *Vergulde Draak*'s pine sheathing is 2.7 cm (maximum preserved thickness 3.8 cm). Like the ship's hull planking and frames, none of the pine sheathing planks were preserved over their full length or width. The maximum preserved length of the pine sheathing fragments is 1.12 m (GT 6026), and maximum preserved width 28.7 cm (GT 98 A).

Eight fragments of pine sheathing clearly show mechanical saw marks, which were mainly preserved near knots where the wood is harder (figs. 5-33 and 5-34).¹⁰⁵ The saw cuts of all these planks are 1.5 mm apart, which is the distance to be expected for seventeenth-century wind-driven sawing when sawing was performed by setting the mill's scroll wheel to two teeth per stroke (figs. 5-35 and 5-36).¹⁰⁶ Simon Jellema, miller of a still-operational wind-driven sawmill, De Rat, in IJlst in the Netherlands, that dates from the seventeenth century, explains that the timber is placed on a sled that is pulled through the mill's sawing frame. The mechanism that pulls the sled can be set to a specific speed that influences the distance between the saw marks. With every wind-driven stroke of the mill, a *haler* draws this preset number of teeth through the mill's scroll wheel, which then pulls the sled through the saw frame. The number of teeth per stroke can thus be regulated. On average, the movement of the sled is 0.6 to 0.7 mm per stroke (by one tooth), which is

FIGURE 5-33.
Fragment of pine sheathing
showing mechanical saw
marks on lower right corner of
interior surface (*top*) from VOC
ship *Vergulde Draak*, GT 6020.
Photographs by Patrick Baker,
Western Australian Museum.



20 cm

FIGURE 5-34.
Detail of pine sheathing from
VOC ship *Vergulde Draak*
showing mechanical saw
marks, GT 1389 C. Photograph
by author.



10 cm



FIGURE 5-35.
Sawing blades of a still-operational wind-driven sawmill (originally built before 1683), De Rat, in IJlst, Netherlands. Photograph by Simon Jellema, miller of De Rat.



FIGURE 5-36.
Saw marks on pine joist used in the construction of the sawmill De Rat in IJlst, Netherlands, sawn mechanically by wind-driven sawmill (17 saw marks per 0.010 m), dating to 1683 or earlier. Photograph by Simon Jellema, miller of De Rat.

relatively slow. Jellema prefers to saw slightly faster, two teeth per stroke, as was done in the past. He states that this tuning should provide a distance between the saw marks of 1.5 mm. The *Vergulde Draak* timbers support his theory.

As in *Batavia*, a thin layer of animal hair (approximately 5 mm thick) was applied between *Vergulde Draak*'s hull and sacrificial planking. Five samples from the hair found



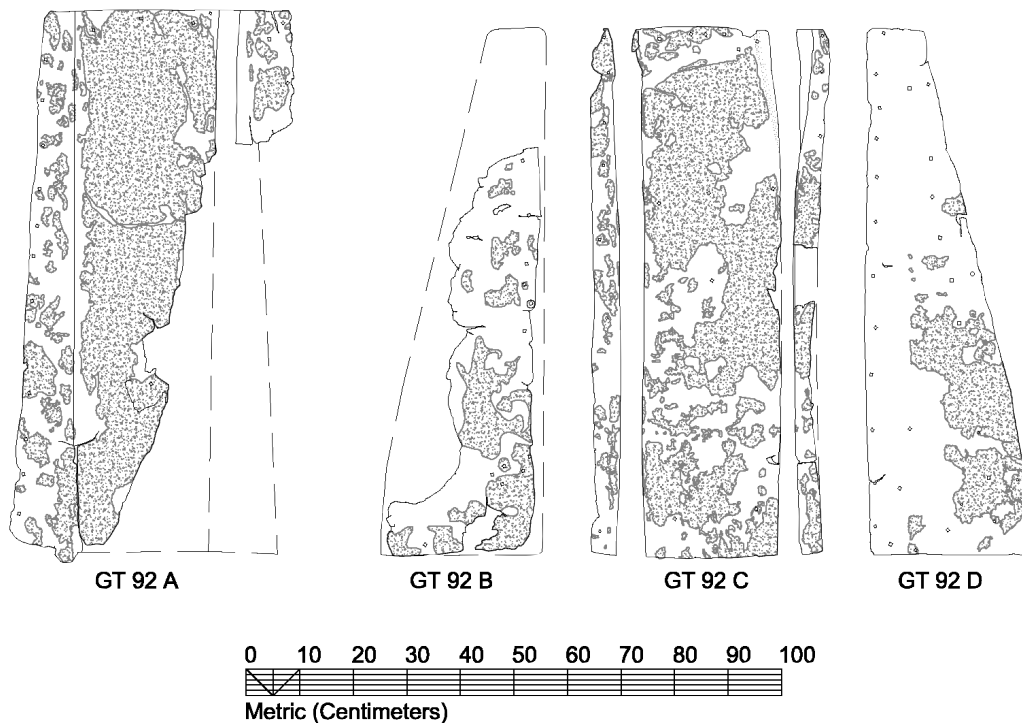
FIGURE 5-37. Goat and cattle hair from *Vergulde Draak* (a, b, c) and *Zeewijk* (d) shipwrecks as seen through a dissecting microscope. (a) “Honeycomb lattice” or “scalloped type” medulla of goat hair sample (200×), GT 98 B. (b) Cattle hair (400×), GT 61. (c) Another strand of cattle hair (400×), GT 61. (d) “Honeycomb lattice” or “scalloped type” medulla of goat hair sample (200×), ZW 5602. Micrographs by Mark van Waijjen, BIAAX Consult.

on the ship’s pine sheathing have recently been identified as goat hair and one as cattle hair (fig. 5-37a–c; table 5-3).¹⁰⁷ In addition to the seventeenth-century hair samples of *Batavia* and *Vergulde Draak*, a sample of animal hair removed from the pine sheathing of the eighteenth-century *Zeewijk* (ZW 5602) was also identified as goat hair (fig. 5-37d). The *Vergulde Draak* hair identified as being from cattle consists of primary guard hairs, which clearly show the diagnostic marker for cattle hair, the so-called globular vacuoles.¹⁰⁸

Additionally, it appears that *Vergulde Draak*’s sternpost was covered with copper sheathing similar to that of the eighteenth-century ship *Buitenzorg* (the ship could simply have carried old copper sheathing from another ship’s sternpost as scrap). Unfortunately, all copper sheathing of *Vergulde Draak* was raised before archaeological intervention in 1972; hence, the exact location of the sheathing on the site is unknown. Its precise loca-

TABLE 5-3. Identification of hair from *Vergulde Draak*'s sheathing

Catalog number	Source of sample	Species
GT 55	Pine sheathing (sacrificial planking)	<i>Capra hircus</i>
GT 61	Pine sheathing (sacrificial planking)	<i>Bos taurus</i>
GT 98 A	Pine sheathing (sacrificial planking)	<i>C. hircus</i>
GT 98 B	Pine sheathing (sacrificial planking)	<i>C. hircus</i>
GT 98 C	Pine sheathing (sacrificial planking)	<i>C. hircus</i>
GT 6020	Pine sheathing (sacrificial planking)	<i>C. hircus</i>

FIGURE 5-38. Exterior surfaces of copper sheets, possibly from *Vergulde Draak*'s sternpost sheathing, GT 92 A–D. Illustration by author.

tion could have helped determine the ship's stern area and consequently have provided a better understanding of how the ship's hull timbers relate to it.

A total of 18 sheets of copper have been identified as sternpost sheathing from *Vergulde Draak* (GT 91, GT 92, GT 1442, and GT 3169). An isometric reconstruction drawing of the sternpost copper sheets has been previously published.¹⁰⁹ Two sets of these copper sheets (one with a lead lining) that make up 8 of the 18 sheets are discussed later. Recent study of a set of 4 copper sheets has demonstrated that 2 sheets nailed on the sternpost's aft face covered 1 copper sheet on each side of the sternpost (fig. 5-38).

The outer layer of copper sheathing (GT 92 A) measures 1.03 m in length and 29.4 cm in width at its aft face (one side has a width of 6.5 to 13.5 cm, and the other, 9 cm). The inner layer (GT 92 C) measures 98.5 cm in length and 25.1 cm in width (plus 4.0 to 4.5 cm



FIGURE 5-39. Copper and lead sheathing, presumably from *Vergulde Draak*'s sternpost. (a) Exterior of outer layer, copper, GT 3169 A. (b) Exterior of inner layer, copper, GT 3169 B. (c) Adjustment patch placed between the side of the inner and outer layers of copper sheathing, GT 3169 C. (d) Interior of innermost layer, lead, GT 1442. Photographs by Patrick Baker, Western Australian Museum.

for each side). One of the side sheets is preserved well (GT 92 D); it is 98.2 cm in length and tapers from 11.5 to 31 cm in width. The other side is preserved over a length of 75.8 cm and has a maximum width of 27.2 cm. All sheets have a maximum thickness of 3 mm, and the cross sections of the square shanks of the sheathing tacks vary from 4 to 6 mm. No sheathing tacks have been preserved in association with these sheets.

In addition to this set of copper sheets, another set of multiple layers of copper sheathing with a lead lining from the sternpost has been recovered from the shipwreck site. This sheathing consists of two copper sheets that fit together and collectively form an outer layer of sheathing (figs. 5-39a–c) that is nailed over a layer of lead sheathing (fig. 5-39d).¹¹⁰ The outermost layer of copper sheathing (GT 3169 A) measures 78 cm in length (of which the lowest 5 cm is bent) and 23 cm in width and has a maximum thickness of 3 mm. The layer of copper sheathing between the outermost layer of copper and innermost layer of lead (GT 3169 B) measures 62.5 cm in length, is 22.5 cm in width (plus a few centimeters for each side strip), and has a maximum thickness of 3 mm. The lead sheet measures 70.5 cm in length, 22 cm in width at its aft face (plus 6 cm in width for each side strip), and 5 mm in thickness.



FIGURE 5-40.
Detail showing
sheathing nail holes
along edge of exterior
of outer layer of
copper sheet, *Vergulde
Draak's* sternpost, GT
3169 A. Photograph by
Patrick Baker, Western
Australian Museum.

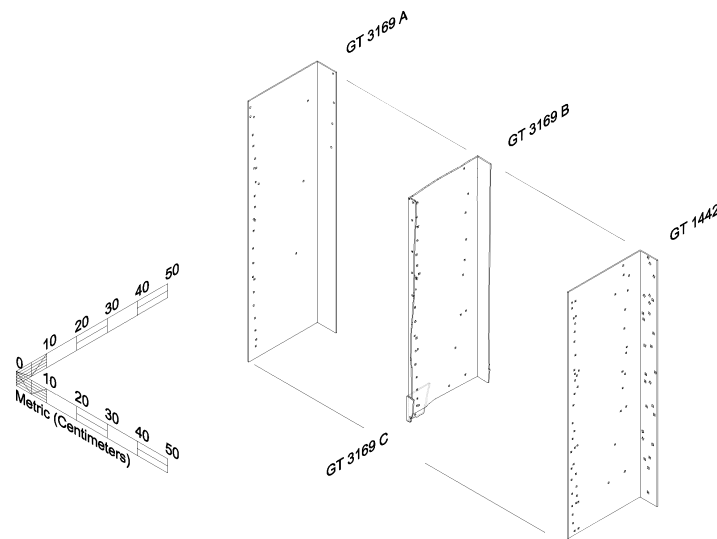


FIGURE 5-41.
Reconstruction of
multiple layers of
Vergulde Draak
sternpost sheathing.
Illustration by author.

The number and arrangement of the nail holes indicate that the lead sheathing was nailed onto the sternpost or rudder first, then one layer of copper sheathing was fastened on top, followed by a second layer of copper sheathing. The nail holes on all sheets clearly indicate the interior and exterior sides of all pieces, as the metal curls inward in the direction the nails were hammered (fig. 5-40). Furthermore, a few nail head impressions are preserved on their exterior surfaces. The impressions indicate that the nail heads vary from 1.4 to 1.6 cm in diameter, whereas the nail holes show that the cross-sectional dimension of the nail shanks varies between 4 and 6 mm in width.

The copper and lead sheets cover the entire aftermost face of the stern post and curl around to the sides of the timber for several centimeters (the sides of the lead sheathing have a maximum width of 6 cm). The lead sheathing was fitted better around the post than the copper sheets, which were not cut wide enough to provide enough coverage. In order to compensate for the lack of copper sheathing on the sides, a small fragment of copper sheet (fig. 5-41, GT 3169 C) was placed at the bottom port side of the sternpost between both the copper layers. This small fragment of copper sheathing measures 7.8 cm in length, 7 cm in width, and 3 mm in thickness.

TABLE 5-4. Results of EDAX analysis of *Vergulde Draak* sternpost sheathing

Sample	Wt (%)					At (%)				
	AsL	FeK	CuK	PbL	Total	AsL	FeK	CuK	PbL	Total
GT 3169 A	1.15	0.36	91.81	6.67	100	1.02	0.44	96.39	2.15	100
GT 3169 A	0.89	0.12	93.95	5.04	100	0.78	0.14	97.48	1.60	100
GT 3169 B	0.67	0.15	95.93	3.26	100	0.58	0.17	98.22	1.03	100
GT 3169 B	0.58	0.12	95.91	3.39	100	0.50	0.13	98.29	1.07	100
GT 3169 C	0.30	1.29	96.15	2.26	100	0.25	1.49	97.55	0.70	100
GT 3169 C	0.42	0.20	96.60	2.77	100	0.37	0.23	98.53	0.87	100

A semiquantitative chemical analysis of three samples from *Vergulde Draak*'s copper sheathing was conducted to determine their approximate composition (table 5-4).¹¹¹ The purity of copper varies between 91.81% and 96.60%. The high concentrations of lead are a result of cross-contamination with lead sheet GT 1442. The copper sheathing from *Vergulde Draak*'s sternpost is, therefore, made of pure copper, not an alloy.

Even though *Vergulde Draak*'s hull remains are scanty and not well preserved, their study has provided clues to the ship's design and assembly. It was built using a bottom-based method in which the ship's bottom hull planking was assembled before the frames were installed. The frames were fastened to the hull planking with wooden treenails that were pegged on their exterior end and wedged on their interior end. The ship's ceiling planking was fastened to the frames and hull planking with treenails, and the ship's riders were fastened to the ceiling, frames, and hull planking with large iron bolts. *Vergulde Draak*'s lower hull was sheathed with a layer of pine planking nailed onto the ship's planking with closely spaced iron nails to create a teredo-worm-repellent iron oxide layer. This sheathing was placed over a thin layer of goat hair mixed with a resinous substance, probably tar. In addition, *Vergulde Draak*'s sternpost was sheathed with multiple layers of copper sheets (with a lead lining). As the discussion has shown, *Vergulde Draak*'s fragmentary hull timbers have provided significant information on Dutch shipbuilding, specifically of large oceangoing ships for long-distance trade.

YACHT AVONDSTER (1659)

Avondster (360 tons) sank on 2 July 1659 while at anchor at the Black Fort in Galle, the most important harbor in Sri Lanka until the nineteenth century.¹¹² This old yacht was in the service of the VOC at the time of its sinking but had previously belonged to the English East India Company.¹¹³ Formerly known as *Blessing*, the ship was captured in Persian waters during the first Anglo-Dutch War on 25 March 1653.¹¹⁴ The ship was dispatched to Batavia carrying the flag of the VOC and a new name, *Avondster*. It is not known exactly when the ship was built, but in *A Calendar of the Court Minutes, etc., of the East India Company, 1640–1643*, it is noted that the English East India Company bought the ship *John and Thomas* on 6 November 1641 and renamed it *Blessing*.¹¹⁵

According to Robert Parthesius, the VOC's decision to call the ship *Avondster* ("Evening Star") suggests that the ship was seen as an aged vessel at the end of its working

life. In the Dutch archives, newly acquired *Avondster* is often referred to as leaky and unseaworthy. *Avondster* set sail once to the Netherlands in 1654 where it may have been extensively refitted.¹¹⁶ It left the Netherlands on 13 March 1655, and after its arrival in Batavia on 8 December, it sailed primarily in Asian waters in service of the VOC until it wrecked in June 1659 while at anchor.

The *Blessing* was approximately 260 tons when in service of the English East India Company. It is mentioned twice in *The English Factories in India, 1642–1645*: on 14 and 19 February 1642, “To Bantam they have sent a ship of 250 tons, called the *Blessing*”; and on 30 October 1643, “the *Blessing* (260 tons).”¹¹⁷ The Dutch, however, referred to *Avondster* as a 360-ton yacht, which may indicate that they refitted the ship.¹¹⁸

Since 2000, the shipwreck has been excavated by the Sri Lankan Maritime Archaeology Unit under the direction of Robert Parthesius.¹¹⁹ Research on the artifacts and hull remains is ongoing, and Christian Murray recently published a preliminary study of the ship’s exposed hull structure in situ in the final excavation report.¹²⁰

The hull structure is preserved exceptionally well considering the wreck’s shallow depth and position in the surf zone close to shore.¹²¹ *Avondster*’s hull settled on the seabed with a 34-degree list to starboard and is preserved up to the upper deck on the starboard side, whereas the port side has been preserved only up to 2.5 m beyond the centerline.¹²² Its main hull structure covers an area about 30 m in length and 8.6 m in width. Generally, sections of the ship’s hull planking and the ends of its futtocks and floors are protruding from the sandy seabed. The after section of the hull is almost entirely covered with sand, except for two large deck beams on the ship’s port side. The stern section of the hull was found separately, about 12 m away from the main hull, which corresponds to contemporary accounts of the ship breaking in two at the stern. This section, 7.5 m long, consists of a part of the ship’s sternpost, keel, and associated planking.¹²³

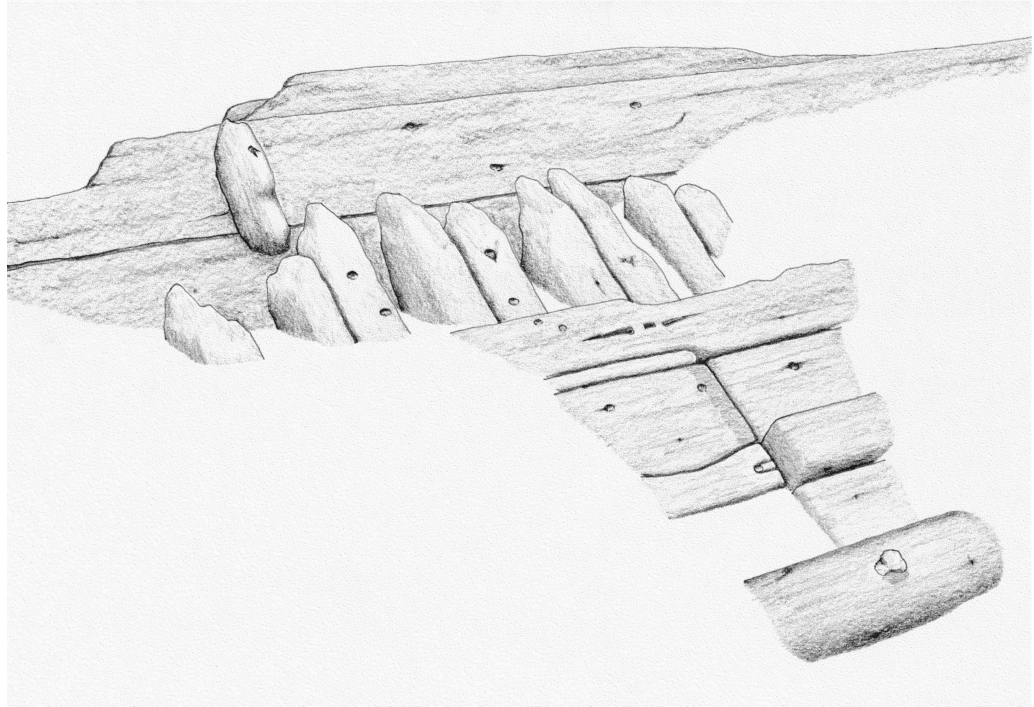
Recent study of *Avondster*’s timbers, mainly directly aft of amidships near the galley, has shown that the ship’s outer hull consists of three layers of planking, two of elm planking (each about 8 cm in thickness) and an additional layer of pine sheathing, varying between 5 and 8 cm.¹²⁴ It is likely that *Avondster* was doubled with an extra layer of hull planking and an additional layer of pine sheathing in 1654 when it was refitted according to VOC standards in Holland to make it fit for tropical waters.¹²⁵

The thickness of *Avondster*’s planking diminishes by one-quarter in the ship’s stern in comparison to the thickness amidships. Murray explains that *Avondster*’s hull planking may have been thinner aft to facilitate the more pronounced curvature and bending of the planks in the ship’s stern (and run into the sternpost).¹²⁶ Although Murray seems to refer to the ship’s hull planking at the stern (no exact location is provided), it is known that transom planking could be one-third thinner than the hull planking.¹²⁷

Preliminary observations from *Avondster*’s bow area suggest that two layers of pine sheathing were used here. Additionally, the ship’s stem seems to have been sheathed or encased with a layer of pine sheathing (see chapter 6, “Pine or Fir Sheathing”). *Avondster*’s pine sheathing was attached to the hull with iron filling nails in a quincunx pattern. The filling nails have a square cross-sectional dimension varying from 5 to 6 mm,¹²⁸ which is similar to that of *Batavia*’s filling nails and those of all ships discussed in this chapter.

Fifteen frame ends on the port side, most likely constituting floors and first futtocks based on their proximity to the centerline, and 11 on the starboard side, possibly second and third futtocks, were studied in situ. The sided dimension of the frames near the

FIGURE 5-42.
Port-side bottom of
Avondster's amidships.
From Murray,
"Interpretation of the
Anglo-Dutch East-
Indiaman *Avondster*
Ship's Construction,"
fig. 9.6.



centerline varies from 10 to 33 cm. No molded dimensions were taken, but Murray does mention that the layers of hull planking and sheathing were thicker than the frames. A few wood samples from the frames have been identified as oak.¹²⁹ A positive identification of the individual frame timbers and their assembly, however, cannot be made because they are covered by ceiling planking and, on the ship's port side, the keelson. Murray suggests that the ship was constructed with double frames, a practice that came into use much later, sometime in the third quarter of the seventeenth century, for the construction of English men-of-war (*Avondster* was a merchant vessel built half a century earlier).¹³⁰ Murray exemplifies his hypothesis with a drawing of the port-side frame timbers, which he earlier suggested possibly compose paired floors and futtocks (fig. 5-42). The drawing may, however, simply show standard frame timbers with floor timber heads and futtock heels exposed underwater.

The remains of a rider were observed on the ship's starboard side, which was bolted to the hull. Oddly, Murray states that "it is commonly asserted that merchant ships had no riders since they reduced capacity."¹³¹ Ships carrying heavy guns, however, such as the yachts and Indiamen in service of the VOC, certainly had riders, as supported by the archaeological examples of *Batavia*, Christianshavn B&W 2, *Mauritius*, and Scheurrak SO1 (see fig. 5-4).¹³² In addition, the VOC construction charters dating to the early seventeenth century specifically refer to application of riders.

The stem, sternpost (with lead and copper sheathing), two concretions of its gudgeons, deck beams, deck planking, spirketting, knees, and a deck clamp have been observed underwater. Rough dimensions are provided in Murray's report, and the identification of wood samples from the sternpost, deck planking, and beams has indicated that they were made of oak.¹³³ Generally, our present knowledge of *Avondster*'s hull remains is too incomplete to make broad generalizations about the ship's construction (specifically

concerning what is typically English or Dutch).¹³⁴ National characteristics have not yet been defined for Indiamen and ships used in long-distance trade. More in-depth research would have to confirm or refute conclusions drawn upon these preliminary observations and provide more conclusive information about the ship's construction, repairs, and refitting.

ARCHAEOLOGICAL EVIDENCE FROM THE LATE SEVENTEENTH CENTURY

In the mid-seventeenth century the first signs of an important conceptual change in shipbuilding appear in Dutch shipyards: the transformation from a bottom-based to a frame-based construction method for large merchantmen and ships of war. As discussed previously, Dutch shipbuilders did not construct their ships according to lines and construction drawings until the early eighteenth century. Even though they may have built ships in Rotterdam and the southern part of the Netherlands using a frame-based method in the late seventeenth century, as suggested by Van IJk's manuscript, it was likely still done by eye and experience.

All VOC shipwrecks examined in this chapter, with the exception of *Avondster*, sailed for the Amsterdam Chamber of the VOC. *Nassau* and *Mauritius* were likely built and outfitted in the VOC shipyard of Amsterdam, and *Vergulde Draak* and the Danish East Indiaman Christianshavn B&W 2 were both possibly built in Zaandam, which was situated in the Noorderkwartier of the Netherlands. None of the ships discussed were built in a shipyard in Rotterdam or the southern regions of the Netherlands.

Comparison of the late sixteenth- and early seventeenth-century ships of long-distance trade to those built in the late seventeenth century is currently problematic. Even less archaeological data are available for the study of ship construction from Dutch East Indiamen and large oceangoing ships dating to the second half of the seventeenth century than from the earlier period. Shipwrecks from this period include the following VOC ships: *Dolfijn* (1663), *Hercules* (1661), *Kennermerland* (1664), *Lelie* (1653), *Lastdrager* (1653), *Oosterland* (1697), *Prinses Maria* (1686), and *Waddinxveen* (1697).

Many publications of shipwreck data from the 1970s state that no hull remains were found, regardless of the excavation's intent, archaeological or commercial. At this time, the realms of scholarly research and methodical excavation were still being refined, and it is not always clear whether archaeologists were specifically referring to an assembled part of the hull or simply did not know what to do with small fragments of hull timber. According to Sténuit, for example, no hull remains were found on the wreck of VOC yacht *Lastdrager*, and similarly there is no discussion of hull timbers in Richard and Bridget Larn's publications on the Dutch Indiaman *Prinses Maria* (1686).¹³⁵ However, they do mention "revealed ship remains" and "huge sections of the vessel's deck timbers are still intact beneath the sand," indicating that hull remains of *Prinses Maria* have been preserved.¹³⁶ It may simply have been a reflection of the development of nautical archaeology from its somewhat lighthearted beginnings to a serious discipline supported by the latest scientific aids. What may have been acceptable 30 years ago should no longer be a legitimate excuse today.

The two large Indiamen *Oosterland* (1,123 tons) and *Waddinxveen* (751 tons), for example, that sank at Cape Town in South Africa in 1697, have been excavated and studied under the direction of Bruno Werz of the Southern African Institute of Maritime Archaeology.¹³⁷ According to Werz, no hull remains of *Oosterland* and *Waddinxveen* were found,

because of the violent wrecking of both ships. During their excavation, very little wood remains were found. Presumably, the timber had washed ashore from both ships and would have been used as construction materials or firewood. The few wooden fragments of the ships' hulls that were found were not diagnostic in most cases. Werz elaborates that any fragments of extant hull wood were left on the seabed because no conservation facilities to preserve the hull wood were available in South Africa. He adds that "no part of the ships' hull has been found, not even a trace of the ship's keel."¹³⁸ This statement seems to indicate that Werz's focus has been mainly on large fragments of hull wood.

As the study of the fragmentary remains of *Vergulde Draak* has shown, even the smallest fragments in poor condition are diagnostic to the trained eye and would undoubtedly have provided some essential information on the ships' construction. Interestingly, in Werz's recently published book on *Oosterland* and *Waddinxveen*, there is a full-page photograph showing a diver recording large hull timber in perfect condition.¹³⁹

Fragmentary hull remains were found of *Kennermerland* (1664), an Indiaman that sank in the Shetland Islands, UK. These fragments indicated that the ship had oak hull planking fastened with treenails and pine sheathing.¹⁴⁰ Although all wooden fragments have been accessioned into the collection of the county museum in Lerwick, their final study has not been published to date.¹⁴¹ Only 20 fragmentary pegged treenails of *Kennermerland* have been published.¹⁴² Like *Vergulde Draak*'s treenails, none of them are preserved over their entire length, and their square pegs are relatively large in cross section.

Unfortunately, little archaeological data pertaining to ship construction and hull remains from late seventeenth-century shipwrecks have been published. In addition, some shipwrecks have yet to be studied. The archaeological remains of *Dolfijn* and *Hercules* in the harbor of Galle, Sri Lanka, and *Lelie* that sank near Texel in the Netherlands, have been relatively untouched and lie well protected on the seabed. Their hull remains, even if fragmentary, can provide important information on the development of VOC shipbuilding in the late seventeenth century. Study of late seventeenth-century VOC ships would provide conclusive evidence on whether the use of double-hull planking had a direct relationship to a bottom-based construction method.

CONCLUSION

Archaeological data from late seventeenth-century Dutch ships are virtually nonexistent in comparison to material dating to the late sixteenth and early seventeenth centuries. Even data from earlier wrecks are scarce when trying to make a comprehensive study of Dutch shipbuilding focused on large oceangoing ships built to sail long distances over the world's oceans.

The hull remains of all late sixteenth- and early seventeenth-century ships discussed in this chapter, with the exception of *Vergulde Draak*, indicate that they were constructed with two layers of hull planking, each roughly of the same thickness. The *Vergulde Draak* seems to be the first example of a Dutch Indiaman from the seventeenth century with a single layer of oak hull planking. The archaeological remains of the VOC ships *Nassau*, *Mauritius*, *Batavia*, *Vergulde Draak*, and *Avondster* and the Dutch-built Danish East Indiaman *Christianshavn B&W 2* have also shown that they were fitted with an additional thinner layer of sacrificial planking or pine sheathing.

Furthermore, the archaeological evidence from the hull remains of almost all shipwrecks discussed in this chapter has shown that they are built using a bottom-based

construction method, typical for northwestern Europe. This type of construction method entails the assembly of the keel, garboard strakes, and bottom planking, which are temporarily fastened with cleats before the framework of the hull is erected. Not much information on *Nassau* is available, and *Avondster* was a refitted English ship, probably built using a frame-based method. The bottom-based construction method and the use of double-hull planking by the Dutch may be better understood if complemented by and compared to historic documentation, as the next chapter demonstrates.

6

DOUBLE-HULL PLANKING AND SHEATHING

The practice of building ships with a double-planked hull seems to have been typical for Dutch East Indiamen, as illustrated by the archaeological remains discussed previously and according to archival documents dating to the late sixteenth and early seventeenth centuries. The earliest references to double layers of hull planking can be found in the manuscripts and journals of the United East India Company and the earlier *voorcompagnieën*.¹

DUBBELING OR VERDUBBELING

The denotation of the Dutch terms *dubbeling* or *verdubbeling* (doubling) are thought to refer to pine sheathing added to a ship's hull below the waterline to protect the hull from marine organisms, specifically teredo worms.² According to historical sources, practically all ships in the service of the VOC had a layer of pine planking or sheathing fastened to the outer layer of hull planking with iron nails.³ In 1697, Van IJk, for example, states that ships destined to sail around the Cape of Good Hope or to the West Indies should be coated with a resinous substance (*harpuis*) from their bottom up to the sides, or above the waterline, and covered with a layer of sheathing, which he refers to as *dubbeling*.⁴

The terms were also used to refer to a second layer of oak hull planking as shown in documents of the *voorcompagnieën* and VOC dating to the late sixteenth and early seventeenth centuries.⁵ A resolution on 6 January 1606, for example, states that a VOC ship was doubled with an extra oak skin on top of which a layer of pine was added.⁶ Subsequently, the terms *dubbeling* and *verdubbeling* were used to refer exclusively to pine sheathing from the late seventeenth century onward when double-hull planking was no longer employed in the construction of Dutch Indiamen.⁷ The terms “doubling” or “to double” will henceforth refer to the Dutch early seventeenth-century practice of adding a second layer of oak hull planking and/or pine sheathing to a ship's hull.

DOUBLE-HULL PLANKING

One of the earliest textual references to double planking is found in a journal of the first two Dutch attempts to sail to China through the northern route in 1594 and 1595. This account includes an inventory of two newly bought ships, *Griffioen* (172 tons) and *Zwaan* (80 tons), and mentions the purchase of 550 pounds (approximately 272 kg) of *harpuis* and 300 pounds (approximately 148 kg) of enriched sulfur to be placed between the old planking and the double planking.⁸

In the first decades after its establishment in 1602, the VOC bought existing vessels and refitted them to build up its fleet. In the earliest VOC shipbuilding charter, dating to 1603, the term “covering” is used for the addition of a second layer of oak hull plank-

ing.⁹ In this manuscript, the inner layer of hull planking is sheathed with lead and hair and then covered with oak planks and doubled up to the quarterdeck wales.¹⁰ Ships that were bought had to be modified and outfitted for the long journeys to Southeast Asia.¹¹ A decree of the Amsterdam Chamber dating to January 1606 mentions an order to double-plank the hull of a large, newly bought ship, *Hercules*, by adding an extra layer of oak hull planking and then sheathing it with pine.¹² A few years earlier, in 1603, when the Amsterdam Admiralty offered its war vessel *Hollandse Tuin* (1,000 tons) for service in the Company's East India trade, the VOC had to double the ship's hull planking at great expense (see fig. 2-3).¹³

During Jacob Le Maire and Willem Corneliszoon Schouten's circumnavigation of the globe between 1615 and 1617, the flagship *Eendracht* (360 tons) collided with a large horned fish in the Atlantic Ocean, a few days south of Sierra Leone.¹⁴ When the damage to the ship was investigated, the broken-off horn of the animal was found stuck in the ship's hull approximately 2 m (7 ft) below the waterline. The horn, equivalent in thickness to an elephant's tusk, had penetrated about 14 cm (6 in) into the hull and was protruding almost a foot from the outside of the hull. The captain, Willem Schouten, who was in the gallery at the after end of the ship at the time of the incident, noticed a great turmoil at the bow and thought a man had fallen off the bowsprit. The horn of the fish must have been broken off with great force, causing the animal to bleed so badly that the water at the bow turned red. Upon removal of the horn, it became evident that the horn had pierced all three layers of the ship's hull, consisting of a thick layer of oak and two thick layers of pine.¹⁵ This may be similar to *Batavia*'s hull, which has one layer of oak hull planking sheathed with two layers of pine between the two lower wales directly above the termination of the double-planked bottom (see fig. 4-22).

The main problem for the VOC, especially in its early years, was the wear and tear on ships engaged in the long journeys to the Indies. Letters and other VOC documents from the early seventeenth century often refer to problems with vessels as a result of their lengthy time at sea and the activity of marine organisms in tropical waters.¹⁶ This problem is discussed in a letter from Holland about the preservation of ships from worms:

Although you have visited our Port (*Amsterdam*), I know not whether you have noticed the ill condition our ships are in that return from the *Indies*. There is on those seas a kind of small worm that fasten themselves to the timber of the ships and pierce them, that they make water everywhere; or if they do not altogether pierce them through, they do weaken the wood so it is impossible to repair them.¹⁷

Most of the vessels in VOC service arrived in the Indies with significant worm damage. In 1620, the Dutch East Indiaman *Morgenster* sailed into the harbor of Sangora (in modern-day Malaysia) and was riddled with worms in some places through all its layers of planking up to its knees or frames.¹⁸ Ships were sometimes replanked or resheathed in Asia from the "keel up" or as much as was necessary.¹⁹

The 1608 journal of Paulus van Caerden, which describes the third journey of the VOC to the Indies, mentions that the large Dutch East Indiaman *Bantam* (700 tons) was not allowed to stay long in tropical waters since the vessel's hull was "undoubled."²⁰ In spite of this warning, the vessel did not return to Amsterdam for over three years after leaving in April 1606.²¹

In his observations during his voyage into the South Sea in 1593, Sir Richard Hawkins discusses various practices to protect ships against teredo worms. He mentions the use of double planking as one means: “Another manner is used with double planks, as thicke without as within, after the manner of furring: which is little better then [*sic*] that with lead; for, besides his waight.”²² The Dutch, however, did not use double-hull planking to prevent worms from devouring their ships. The outer layer of pine sheathing and the iron nails used to attach it served this purpose. The nails corroded rapidly, and the iron oxide spread readily through the layer of pine, creating a toxic, protective layer as a worm guard.²³

According to Arent Vos, double planking is a result of the transition from lapstrake to carvel-planked vessels. He argues that Dutch shipbuilders could not immediately distance themselves from the concept of a self-supporting skin with overlapping planks and compensated for the lack of overlapping planking with a double layer of planking.²⁴ This may have been true if Dutch ships were constructed entirely using a shell-first method with lapstrake planking. Dutch ships, however, did not have a completely self-supporting skin because they were built using a bottom-based method; they had only a self-supporting bottom assembled without the support of frames. Furthermore, these bottoms, which dictated the initial shape of the vessels, had been built in a carvel-planked manner for many centuries.

Hocker suggested that planking a hull with two layers may be a solution to one of the problems related to the assembly of freestanding planks during the ship’s construction, the stabilization of the planks before the frames are inserted.²⁵ The second layer, however, was added to the first layer of hull planking *after* the framework was installed. Therefore, stabilizing the planks during construction does not appear to have been the reason for the doubling.

The lower part of the ships’ hulls may have been double-planked to ensure watertightness for valuable freight and to protect the hull from damage during the long voyage. According to Witsen and Van IJk, ships with an overall length (from stem to stern) of 120 to 140 Amsterdam ft (34 to 40 m) should have hull planking with a thickness of approximately 4 Amsterdam thumbs (0.103 m).²⁶ Van IJk also lists a planking thickness of 4 thumbs for a vessel 154 ft (43.6 m) long.²⁷ A shipbuilding charter endorsed by the VOC on 24 May 1653 also lists a planking thickness of 4 thumbs up to the first wale. In addition, Witsen mentions that the garboard strake of a vessel 130 ft (36.80 m) long would be 22 to 24 thumbs in width (0.56 to 0.61 m).²⁸ A plank 10 m long, 0.56 m wide, and 0.10 m thick would then weigh approximately 347 kg, depending on the species of oak.²⁹ The heavy weight of the planks that made up the strakes likely caused problems when bent into the proper shape without the support of frames.³⁰ It is more difficult to bend one thick plank into shape and keep it in place than it would be to do the same thing with two thinner planks. It is simply easier to bend a thinner plank if there is no framing to bend against.

While textual evidence shows strict standards for planking thickness, the archaeological evidence does not always correspond to the prescribed measurements. An average planking thickness of 4 Amsterdam thumbs for ships ranging between 120 and 140 ft in length, as given by Witsen and Van IJk, does not correspond with the 0.14 m (5 thumbs) thickness of the double layer of planking of the Scheurrak SO1, which belonged to that class.³¹ The total thickness of the layer of double planking of *Mauritius* also exceeds the average thickness listed by Witsen and Van IJk. The common planking thickness of a

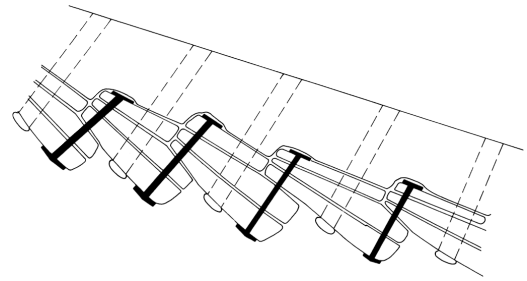
vessel between 150 and 170 ft (42.5 and 48 m) in length should be 4.5 thumbs (0.116 m).³² The hull planking of the early seventeenth-century ships such as *Mauritius*, *Batavia*, and *Nassau* are much thicker than expected. The garboard strake of *Mauritius* has a total thickness of 0.18 m; the second strake, 0.16 m; and the remainder of its hull planking, 0.14 m. The average planking thickness of *Batavia* is 0.16 m for both layers of oak planking strakes. Moreover, *Nassau*, a much smaller ship than *Batavia* and *Mauritius*, has a maximum planking thickness of 0.16 m as well.³³ It must also be noted that the planking thickness (3.5 thumbs, or 0.09 m) of the mid-seventeenth-century *Vergulde Draak* perfectly conforms to the VOC shipbuilding charter of 24 May 1653. Furthermore, the planking thicknesses of *Buitenzorg* (0.105 m), an 880-ton ship built in 1753, and *Nieuw Rhoon* (0.102 m), an 1,150-ton ship built in 1764, do correspond to the average planking thickness for ships between 120 and 140 ft long, as given by Witsen and Van IJk in the late seventeenth century.³⁴ *Vergulde Draak*, *Nieuw Rhoon*, and *Buitenzorg* also had one layer of oak hull planking.

It may be that the VOC increased the thickness of the hull planking in the early seventeenth century to increase the strength of its Indiamen so the vessels could better endure the rough journeys to the Indies and perhaps stay in the company's service a bit longer. Witsen does mention that flutes sailing to the Indies are built much stronger than flutes sailing in European waters. He does not, however, refer to double-hull planking or thicker hull planking but describes the use of stronger frames and large lodging (knees) in the bow and stern.³⁵ Van IJk observed the construction of a vessel (155 ft, or 44 m, in length) that was going to sail around the Cape of Good Hope and recorded a planking thickness of 6 thumbs (0.15 m), which was in his opinion excellent craftsmanship in order to make a strong ship.³⁶ The planking thickness of this ship is 1.5 thumbs thicker than the average of 4.5 thumbs listed for a ship this size and corresponds with the planking thickness of the *Mauritius*. In a report dating to 1615, written by a Frenchman who had been imprisoned by the Dutch expedition circumnavigating the world between 1614 and 1617 under the command of Joris van Spilbergen, it is stated that both the admiral's ship of the Dutch fleet, *Grote Zon*, and the vice-admiral's ship, *Grote Maan*, each 600 tons, were very strong ships with double layers of hull planking.³⁷ He elaborates that regardless of their thick hulls, the Spanish cannon balls did manage to penetrate them.³⁸ Both *Grote Zon* and *Grote Maan* were warships from the Amsterdam Admiralty that the Admiralty doubled and equipped for their planned circumnavigation in the service of the VOC.³⁹

The VOC's solution to the additional strength requirements of large hulls was, thus, focused primarily on the laminated outer shell of planking. It is the most obvious answer for the construction of large ships using a bottom-based or shell-based method. A similar solution was used for the construction of large ships in the ancient Mediterranean, as evidenced by the Madrague de Giens ship. This large Roman merchant ship, dating to the first or second century BC, was constructed by a shell-based method with two layers of hull planking. The ship measured about 40 m in length and 9 m in beam.⁴⁰ The first evidence for the use of multiple layers of hull planking in northern Europe comes from the large medieval naval ships built for the English Crown. These large warships were constructed by a shell-based method with lapstrake planking.

The archaeological remains of *Grace Dieu*, also known as the Burlesdon ship, indicate that each strake of the ship's hull planking consisted of three layers of planking.⁴¹ The 1,400-ton *Grace Dieu*, launched in 1418 by Henry V to serve in the Hundred Years War,

FIGURE 6-1. Reconstruction drawing of the triple layer of hull planking of the R. Hamble wreck at Buresdon, or Henry V's *Grace Dieu* of 1418. Illustration from Clarke et al., "Recent Work on the R. Hamble Wreck," fig. 5.



was the largest ship constructed in Europe at the time. This two-masted carrack had an overall length of 180 ft (54.86 m) and a beam of 50 ft (15.24 m). The ship's keel was 125 ft (38.10 m) in length. *Grace Dieu* was struck by lightning and partially destroyed 21 years after its construction.⁴² The archaeological remains of the Buresdon ship have provided important evidence that large and heavy ships could be built using a shell-first construction method with lapstrake planking.

Three layers of planking that make up each of *Grace Dieu*'s planking strakes are fastened together with small nails to form one thick composite plank.⁴³ This, however, conceptually differs from the Dutch-built ships, in which the second layer of hull planking was not added to the first layer before they were erected but much later in the construction process (after the frames were installed). The inner layer of the Buresdon ship's composite planking was about 4 in (0.102 m) narrower at its bottom than the two outer ones. The two wider layers of this strake overlapped the three planks of the strake below and were fastened to it with iron nails riveted over roves (fig. 6-1).⁴⁴ Thus, the overlap of the planking strakes consisted of five layers of planking. After the planking was assembled, the ship's joggled frames were installed and fastened to the thick triple planking strakes with wooden treenails.⁴⁵ For the construction of *Grace Dieu* and its attending vessels 3,906 trees were felled, including 2,735 oaks and 1,171 pine, ash, and elm trees.⁴⁶

Ian Friel's study *The Good Ship* has shown convincingly that the enormous total length of planking needed for the construction of each individual English warship, as listed in the royal navy records, is so long that they must have been double- or triple-planked like *Grace Dieu*. He explains that for the construction of the Graveney boat, 830 ft (253 m) of planking was used. This local watercraft has an estimated length of 13.75 m and was built with 11 strakes of planking on each side of its keel. Friel provides lengths of planking used for three of the royal galleys built in 1295: "[one] built at Southampton (60 oars; 12,444+ ft/3794+ m), Ipswich (100 oars; 7600+ ft/2317+ m) and Lyme (54 oars; 6200+ ft/1890+ m)." He continues: "The smallest of the 1295 galleys used at least seven times as much planking as the Graveney boat. Even allowing for extra decking, and the probability that the galleys were at least twice the size of the earlier vessel, the difference is considerable."⁴⁷

The Dutch may have known about medieval English shipbuilding practices, but the application of double-hull planking was more likely a direct result of the lengthening of existing ships, which had started to occur more frequently in the late sixteenth century. An archaeological example of a lengthened vessel, or *verlanger*, is the Christianshavn B&W 1, built shortly after 1584 and lengthened sometime after 1608. This ship was double-planked only in the forward and aft section of its hull, whereas the newly added midsection, 7.70 m long, was single-planked. The second layer of hull planking in the fore and aft hull (9.60 m and 9.10 m long, respectively) was added when the ship was lengthened and

ran over the entire length of the ship (hence, this is the single layer of its midsection). It was fastened to the inner layer of planking with wooden treenails (diameter 0.03 m). The thickness of the original inner layer and the new outer layer of hull planking in the bow and stern was 0.045 m (in total, 0.09 m at the extremities). Directly forward of the inserted section on the port side, three pine boards were inserted between the inner layer and new outer layer of hull planking. These boards were 1 m in length and taper from a thickness of 0.035 m fore to 0.02 m aft (where they stop at the first nearby frame of the new central section of the hull). Lemée suggests that the addition of these boards would have provided a better curvature of the ship's hull because they widened the hull and therefore created a rounder hull shape in the ship's center. When the ship was lengthened, three additional bilge stringers were inserted for additional longitudinal reinforcement (varying in thickness from 0.10 m to 0.15 m).⁴⁸

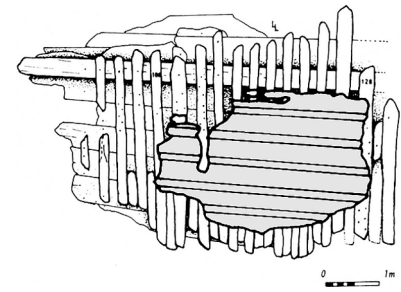
According to Wegener Sleswyk there must have been two basic methods of strengthening a ship's hull when lengthening it: by adding more planking to the ship's exterior or by adding thicker ceiling planking in the interior.⁴⁹ Both methods have been applied in the rebuilding or lengthening of the Christianshavn B&W 1.

The use of two layers of hull planking as seen in Dutch-built large merchantmen, East Indiamen, and yachts was, therefore, likely to have been directly influenced by the practice of lengthening ships in the same period. And even more likely since Pieter Jansz Liorne, who must have been intimately familiar with this practice, would provide technical advice to the VOC, as discussed previously.

While the bottom-based construction method continued to be used on inland craft until the disappearance of the wooden hull,⁵⁰ frame-based construction became prevalent in the Admiralty and VOC shipyards in the early eighteenth century, when its VOC shipwrights seem to have abandoned the practice of double-planking hulls for decades. The last-known archaeological example of a Dutch ship in service with the VOC built with two layers of hull planking and a layer of sheathing is *Avondster*. If the yacht was indeed doubled with an extra layer of hull planking and an additional layer of pine sheathing in 1654, when it was refitted in Holland, then the VOC still outfitted its ships with a double layer of hull planking into the 1650s.⁵¹ By the same token, *Vergulde Draak*, bought in 1653, was built using a bottom-based method, albeit with one layer of oak hull planking (plus a layer of pine sheathing). It is unknown precisely when *Vergulde Draak* was built. Although Van IJk writes that a frame-based construction method was used in the southern parts of the Netherlands, archaeological evidence for large oceangoing merchantmen built using a frame-based method dating to the late seventeenth century is not yet available.

According to Hocker, neither Witsen nor Van IJk mentions double-hull planking.⁵² Witsen does not, but Van IJk does mention it in his manuscript on shipbuilding published in 1697. He even suggests the construction of double-hull planking as the solution to a problem with the ceiling planks and bilge stringers in the hold (between the upper deck and bilges). The water running down from the sides into the hold settles on the ceiling and stringers and causes significant rot. This affects the strength of the ship in both the longitudinal and transverse directions. Van IJk recommends all master builders to consider reinforcing hull strength of new large ships with a double layer of hull planking from the turn of the bilge to the first wale and omitting the rot-prone ceiling planks between the upper deck and the turn of the bilge.⁵³ It is interesting that Van IJk makes

FIGURE 6-2. The ceiling planking between frames 106 and 128, VOC ship *Mauritius*. Illustration by Michel Rival, in L'Hour, Long, and Rieth, *Le Mauritius*, 214. © CASTERMAN S.A.



this suggestion in a period when double planking was probably no longer employed for large merchantmen.

Van IJk's proposition is the same as Ab Hoving's suggested possibility for the construction of ships with two layers of hull planking. The addition of a second layer of hull planking, about a meter in width around the ship's waterline, can increase the stability of a ship. It makes a ship slightly broader around the waterline and thus provides a girdle that increases stability.⁵⁴ The use of double planking around the waterline may indeed have stabilized or girdled a ship better, but at that time the Dutch-built VOC ships were double-planked from their keel up.

Furthermore, the 12 strakes of ceiling planking of *Batavia* cover the entire preserved stern side of the ship (above the bilges). The ceiling planking varies from 0.06 to 0.07 m in thickness at the ship's bottom and from 0.08 to 0.09 m at the sides. The ceiling planking found on *Mauritius* is located at the bottom of the ship's hold next to the keel between frames 106 and 128 and is treenailed to the frames, presumably the floors (fig. 6-2).⁵⁵ It has an average thickness of 0.08 m, and the width of the ceiling planks varies from 0.30 to 0.55 m.⁵⁶ Its thickness is equal to that of one layer of hull planking and must have added significant strength to the ship's hull. The hull remains of *Mauritius* are, however, insufficient to conclude whether or not the ceiling planking extended beyond the bilges.

The VOC no longer employed a double layer of hull planking in the late seventeenth century, but ships used for whaling or navigating in polar waters continued to be double-planked to protect the hull from the impact of collisions or crushing if they became icebound.⁵⁷ Vos argues that these whaling ships had to be reinforced to withstand the rough conditions in cold polar waters but that the double planking of large seagoing ships was unnecessary.⁵⁸ However, the tropical waters and the long voyages to the Indies took a heavy toll on the hulls of the VOC ships, and a thicker hull may have been considered essential. Reinforcing a hull, when using a bottom-based construction method, was made easier by the assembly of two layers of oak planking instead of one. This eliminates the need for excessively thick planking strakes. In addition, two thinner layers of hull planking are easier to repair en route should the need arise. Regardless of the hull's division into multiple layers, this type of construction requires large quantities of good-quality, straight trees to facilitate the thick planking strakes. In double-planked hulls the space between the planks is filled with fiber and a resinous substance, and then the seams are staggered so that those on the inner and outer layers do not align. This makes for much tighter hulls with fewer leaks.

Ships in service of the VOC in the early seventeenth century, such as Indiamen, flutes, and yachts, were subject to similar requirements regarding their outfitting because all of

these types of ships were not considered capable of sailing to the Indies unless they had two layers of hull planking and a layer of pine sheathing.

Dutch ships of exploration in service of the *voorcompagnieën*, and later the VOC, were obviously outfitted differently than, for example, the warships of the Amsterdam Admiralty. It is interesting to note that the VOC added double planking to the warships *Grote Zon*, *Grote Maan*, and the four-masted *Hollandse Tuin*. This makes the ships of the *voorcompagnieën* and VOC planked more heavily than the warships of the Admiralty, since the VOC went through the effort to rebuild Admiralty ships offered to its service in order to make them more adequate to withstand tropical waters, storms, and enemy attack.

LEAD AND COPPER SHEATHING

Lead sheathing, like that used between the hull planking layers and the planking and sheathing of *Mauritius* and *Nassau*, seems to have been commonly used in the earliest years of the VOC's establishment. The VOC Chamber of Amsterdam purchased a ship of 360 tons from Brother Sijmons van Hinlopen in May 1603. On 19 August 1603, the VOC's Gentlemen XVII decided to make the ship ready for a voyage to the Indies, so the hull needed to be refitted with lead and pine sheathing.⁵⁹ According to shipbuilding decrees of the VOC dating to the early seventeenth century, new ships built in Amsterdam had a layer of pine and lead sheathing up to the first wale of the quarterdeck.⁶⁰ An account of the VOC lists several materials used for the doubling of the Dutch East Indiamen *Amsterdam* and *Zon*, which includes 207 rolls of thin lead sheathing weighing 14,859 pounds (approximately 7,207 kg).⁶¹

Sheathing with lead appears to have been a short-lived practice of the VOC. In 1606, it is specifically mentioned pine sheathing should be applied without a layer of lead to the hull of *Hercules*.⁶² "Without lead sheathing" seems to be purposely mentioned for a short period of time around 1606, after which the VOC generally no longer added layers of lead sheathing between the planking of its Indiamen.

Lead sheathing was considered costly, heavy, and not durable. Richard Hawkins noted, "In Spaine and Portingall, some sheathe their shippes with lead; which, besides the cost and waight, although they use the thinnest sheet-lead that I have seene in any place, yet it is nothing durable, but subject to many casualties."⁶³ However, it can be said with certainty that the material costs of lead could not have influenced its abandonment. *Amsterdam* and *Zon* were sheathed for about 167 guilders in 1604, which is a negligible amount in comparison with the overall expenditure of building a large Indiaman (estimated to have cost roughly 100,000 guilders).⁶⁴ It is not known whether the Dutch discontinued use of lead sheathing because of the high maintenance, its weight, or its electrolytic reduction in the vicinity of iron fasteners.⁶⁵ Lead sheathing did add several thousand kilograms to a ship's hull.

From the journal of *Mauritius* (250 tons), a ship that circumnavigated the world with Olivier van Noort between 1598 and 1601, it is known that the ship's stern rudder was sheathed with lead. On 25 October 1600, the rudder was resheathed at the island of Capul in the Philippines because its lead sheathing had fallen off.⁶⁶ So, in addition to the ships' hulls and sternposts, their rudders may have been sheathed in lead as well. Witsen states in his manuscript, published in 1671, that copper or lead sheathing for Indiamen was optional, which indicates that it was not standard practice in the late seventeenth cen-

ture.⁶⁷ In its early years, the VOC was obviously experimenting with different methods of sheathing in order to find the most ideal combination for its East Indiamen.⁶⁸

The Dutch West India Company supposedly experimented with the copper sheathing of its ships in the early seventeenth century. According to a late eighteenth-century Danish publication, Dutch admiral Piet Hein put copper sheathing to use first, but then it was abandoned until reintroduced by the English in the eighteenth century.⁶⁹ Furthermore, English shipwright William May, who worked for the Amsterdam Admiralty in the late eighteenth century, mentioned that he “recollects to have read somewhere that the ship with which Admiral Piet Hein had sailed to Brazil was coppered.”⁷⁰

One of Piet Hein’s ships, *Hollandia*, sank off the coast of Brazil in 1627. Its wreck site was found a few decades ago and, unfortunately, salvaged. All artifacts were sold off at Christie’s in the 1980s, and some coinage was reoffered for sale more recently by American Numismatic Rarities.⁷¹ This shipwreck could have provided key evidence for the use of copper sheathing much earlier than the eighteenth century if it had been subject to proper archaeological research.

Van IJk mentions that in the late seventeenth century the stem and sternposts of ships destined to sail around the Cape of Good Hope or to the West Indies were sheathed with copper to keep the wood-eating worm away.⁷² Archaeological evidence has shown that it was standard VOC practice to sheathe the sternposts of its ships with copper sheets (fastened by copper sheathing tacks) throughout its entire existence. The archaeological remains of *Nassau* (1606), *Batavia* (1629), *Vergulde Draak* (1656), and *Buitenzorg* (1760) have all shown that their sternposts were sheathed with copper. The preserved sheathing on *Batavia*’s sternpost consisted of a single layer of copper sheets, whereas *Vergulde Draak*’s sternpost was covered with multiple layers of copper with a lead lining.

The sternpost of *Buitenzorg* demonstrates that it was coppered with sheets that covered the sternpost’s after face and about 10 cm on each side. The sides of the sternpost were sheathed with pine. No copper sheathing was found on the lower hull planks that ran into the ship’s sternpost and that were raised with the sternpost assembly. Although the after face of the sternpost was sheathed mainly with copper, it was sheathed with lead directly beneath its iron gudgeons.⁷³

No archaeological evidence has been found to date that demonstrates copper sheathing of the ships’ stem for any seventeenth- and eighteenth-century Dutch oceangoing ships.

RESINOUS PAYING MATERIALS

In his manuscript on shipbuilding, Witsen lists the ingredients of a “porridge” with which ships were coated from the bottom to above the waterline. It consisted of *harpuis*, low-grade resin, whale oil, and sulfur.⁷⁴ In Van Dam’s glossary *harpuis* is described as a mixture of resin, whale oil, fat, and sometimes sulfur. It was not only used to protect the ship’s hull against worms and weathering but also to prevent rot of mast and spars. The word derives from the French *poix* (Old French, *harpois*), which means “resin, pitch, or tar.”⁷⁵ Van IJk, however, explicitly writes that *harpuis* is a juice or gum that flows from French pine trees and is burned. He then specifically refers to pitch.

This resinous substance was imported into the Netherlands in disks, each weighing between 120 and 180 lb (approximately 59 and 89 kg) at a cost of 4 to 5 guilders per 100 lb (49.4 kg). Van IJk adds that it was much more expensive in time of war. This *harpuis* was mixed with sulfur, which created a white substance, and applied to the ship’s hull on

the inside, outside, and above the waterline. According to Van IJk, sulfur was imported mainly from the Aeolian Islands near Sicily, although the best quality came from a small island or promontory of Molo along the Italian coast. It was also found in the Italian Apennine mountain range. It used to cost 5 guilders per 100 lb but apparently had become more expensive in Van IJk's time, as he mentions a price of 10 guilders per 100 lb. The most expensive sulfur had the deepest yellow color.⁷⁶

A layer of wax and a resinous paying material was applied first to the exterior of the planking layers, and then a thick coating of animal hair was added to create waterproofing with a teredo worm repellent.⁷⁷

PINE OR FIR SHEATHING

According to a letter written by Jan Pieterszoon Coen on 10 November 1614, all Dutch ships in service of the VOC in Jakarta were sheathed with a layer of pine planking to protect the ships from teredo worm infestation. Coen refers to the resheathing of ships on a regular basis and, if needed, before they set sail to the Netherlands. With the exception of foreign prizes, all ships built in the Lowlands were double-planked and sheathed as a matter of maintenance. Captured ships were also doubled and refitted at shipyards in the Indies to meet VOC requirements. The resheathing or replanking of VOC ships was generally done every two to four years, depending on the condition of a vessel.⁷⁸ A letter written in 1634 from Batavia states that ships purchased by the VOC require more maintenance than those built in-house.⁷⁹

The archaeological remains of all VOC ships, such as *Mauritius*, *Batavia*, *Vergulde Draak*, *Avondster*, *Kennermerland*, *Risdam*, *Zuiddorp*, *Zeewijk*, *Buitenzorg*, and *Nieuw Rhoon*, have provided evidence for such protection.⁸⁰ Pine sheathing and resinous paying materials with animal hair were used as a protective layer on ships' hulls throughout the seventeenth and eighteenth centuries.⁸¹ The hull remains of *Buitenzorg* indicate that the quincunx pattern of the sheathing nails was laid out carefully by an incised pattern of diagonal lines scratched into the exterior surface of the ship's pine sheathing. Where two incised lines cross or intersect, a sheathing nail is hammered in.⁸² The incised pattern certainly facilitated spacing the nails out evenly and, hence, ensured a more even buildup of the corrosion products that inhibited the invasion of teredo worms.

The archaeological remains of *Batavia* demonstrate that the sternpost of the ship was encased by a layer of oak planking and an additional layer of pine sheathing. Furthermore, the keels of the Christianshavn B&W 2, *Mauritius*, and *Buitenzorg* were protected by pine sheathing. The Christianshavn B&W 2 shows two layers of cover planking on each side of its keel and false keel, but it is not clear whether both are pine or if the inner is oak and the outer is pine.⁸³

Buitenzorg was built at the Amsterdam shipyard in 1753.⁸⁴ The ship sank upon return from its second voyage to the Indies after it had become icebound between Texel and Den Helder in January 1760.⁸⁵ In 1958, part of the ship's keel, sternpost, stem, and deadwood were raised. Even though the fragmentary bow assembly has not been subject to scholarly study and publication, the many closely set nail holes on either side of the stem and keel indicate that they were sheathed.⁸⁶ Preliminary observations of *Avondster*'s hull remains also suggest the use of pine sheathing to protect the ship's stem.⁸⁷ Reference to such application had already been made much earlier in the journal of Jan Huygen van Linschoten's second attempt to sail to the Indies through the northern route in 1595. The wooden

sheathing of a ship's stem, probably that of the *Griffioen*, was torn off when the ship ran into a submerged rock during a storm near Norway's North Cape.⁸⁸ It is therefore likely that the stems of Dutch ships of exploration and VOC ships were protected with a layer of pine sheathing from the late sixteenth century onward.

The shipyards of the VOC Chambers had to follow the company's regulations as prescribed in its shipbuilding charters, but they did not conform to specific norms concerning the details of the construction and outfitting of their ships. There were certainly regional differences. In a letter from Batavia dated to 27 December 1634, suggestions are written down for the VOC in the Netherlands regarding the sheathing of ships with the intention of decreasing work for the ship carpenters in the Indies.⁸⁹ It is also recommended that the nails fastening the pine sheathing should be set as closely as done by the Amsterdam Chamber, because the dense layer of rust on the bottoms of the Amsterdam ships repels worms miraculously.

At the shipyards of the VOC Hoorn Chamber, nails are supposedly set even closer than in Amsterdam, which is considered preferable, as the skin becomes almost indestructible through the rust layer. The nails should be short and have heads larger and thicker than usual. As shown in the previous chapters, the heads of the sheathing nails of the Amsterdam Chamber ships generally had a diameter of 0.015 m (*Mauritius*, *Batavia*, and *Vergulde Draak*), slightly smaller than the heads of the large spikes used in *Batavia*'s construction. The 12 December 1634 letter also states that the "boat oak" used by the VOC Enkhuizen Chamber to sheathe the bows of its ships bends easily and stays in place beautifully but is also very "sweet" to worms, which results in continuous work for the carpenters in the Indies. It is, therefore, recommended to sheathe with pine only, "as iron corrosion does not spread well through oak [because of its higher density] and pine is much cheaper."⁹⁰

The time required to add extra layers of planking varied from a few weeks to several months depending on the size of the ship, the amount of work that needed to be done, availability of resources and craftsmanship, physical circumstances, and the weather.⁹¹ An account from Zeeland, dating to 1595, tells us that the newly bought Dutch ship *Griffioen* was outfitted for its journey to the Indies via the hypothesized Open Polar Sea by 15 carpenters in 16 days. This outfitting included stripping the ship's planking down from the channels (embedded in the upper part of the wales), renewing the vertical support timbers on the after side of the hull overlaying the wales, taking apart and rebuilding the stern, renewing the lower deck over the entire length of the ship, and adding a second layer of hull planking and a new permanent *boevenet* aft of the mast (probably a quarterdeck).⁹²

PORTUGUESE ACCOUNT OF THE CONSTRUCTION OF AN EARLY SEVENTEENTH-CENTURY VOC SHIP

An account written by António Durão, a Portuguese soldier stationed in the Mozambique fortress of São Sebastião, recounts two Dutch blockades of the Portuguese stronghold in 1607 and 1608. Durão describes the VOC ship *Zierikzee* and its structural features.⁹³ The ship had foundered at Cabacella on 16 May 1607 while under fire from the Portuguese bastion. After the ship's crew and stores had been evacuated, as ordered by Admiral Paulus van Caerden, the Dutch set the vessel ablaze.⁹⁴

Zierikzee was a large Indiaman that had been in service of the VOC since 1602 and was

sailing for the Chamber of Zeeland when it was abandoned. Listed in the VOC archives as a 760-ton (380-*lasten*) vessel, it was downsized to 500 or 600 tons (250 or 300 *lasten*) for its third and final VOC voyage.⁹⁵ Prior to its acquisition by the Chamber of Zeeland, it had belonged to one of the Dutch joint-stock companies, for which it journeyed to the Indies at least once.⁹⁶ The ship, therefore, was a well-traveled veteran by 1607. Several of the Portuguese who went to claim the ship apparently had some knowledge of ship construction and found particular features of *Zierikzee*'s hull noteworthy. Durão recorded their observations, which support the assertions on sheathing discussed earlier. The hull had multiple layers of planking alternating with lead sheathing and had a coppered stern-post:

Those who went to get the spoils from the lost nao [ship] noticed its construction and composition. Thus, it seemed to me good to mention how it was. It was a ship with three layers made very sturdy and of good timber, and in between each layer it had another of lead to cool the timber so that, with the heat, it would not rot; and from the keel upwards, it had an outer layer of pine two fingers thick on top of which was “*gala gala*” of certain hair mixed with tar and pitch to preserve the animal [hair] and make it last longer.

All the [compartments of the] holds were lined with Moorish brass [= Moroccan copper] so that the victuals would not rot or get wet. It had no chain plates and no wales, nor shrouds, and the stern was closed without more veranda than a berth where the captain slept. The entire rudder was lined with the same brass [= copper] plates so that it could not burn, nor rot. It had a “*patana*” [keel plank?] and not a keel. And in this way they say that all their ships are, and like this [one] they are extremely solid and light and less risky in the shallows since they draw less water. And they are safer in storms.⁹⁷

The three layers in Durão's account most likely refer to two layers of oak hull planking and one layer of pine sheathing. He mentions that the outer layer of pine sheathing was two fingers thick (± 0.04 m), which is in accordance with historical and archaeological evidence.⁹⁸ Puzzling is the comment that *Zierikzee* had no keel but possibly a keel plank, as there is no doubt that large Indiamen had a sturdy keel covered with pine or oak sheathing, as demonstrated by *Mauritius* and Christianshavn B&W 2. The absence of chain plates and shrouds may have been a result of the ship's evacuation of stores and equipment, perhaps when they were taken off, or they may have been burned. Durão points out a lack of wales in the ship's construction, but the outer layer of oak hull planking would have obscured them, since early seventeenth-century VOC ships were double-planked up to the underside of the quarterdeck wales. Also, the wales had the same thickness as the two layers of planking.⁹⁹ Nevertheless, the Portuguese description of *Zierikzee* is an important addition to contemporary Dutch archival documents.

DOUBLE PLANKING OR SHEATHING SHIPS ABROAD

Fifteen fleets traveled to Asia between the first Dutch journey to the Indies in 1595 and the founding of the VOC in 1602.¹⁰⁰ In this period, there were no permanent stations in the Indies for ships to be repaired. If severe leaks or damage occurred to the

hull, ships were anchored in the nearest safe bay for repair.¹⁰¹ These temporary stations had no readily accessible facilities, and the ship's crew had to work with limited available resources. They had to set up a shipyard and camp, unload the ship, heel it over to expose the bottom of the hull, and obtain materials such as planks.¹⁰² This alone could take several months. In addition, a chronic shortage of carpenters—this was evident throughout the entire seventeenth century—sick crews, and bad weather could delay repairs further.

In December 1603, the fleet of Joris van Spilbergen, sailing for the Company de Moucheron, had an encounter with the yacht *Jager* in the waters off St. Helena. Here, they learned that *Jager*'s chief merchant, Willem van Haghen, had anchored in Mauritius and wintered on the island for four months to repair his ship. He had set sail from Bantam in March 1602 but did not dare pass the Cape because the ship was severely leaking. In Mauritius, *Jager* was unloaded, heeled over, and repaired.¹⁰³

Replanking or sheathing in foreign waters could take much longer. In 1603, for example, the ship *Leiden* was heeled over near Patani (modern-day Thailand), where one side of the hull was doubled. It took the crew seven months to do so. Skipper Hendrik Jansz had set sail with *Leiden* from Texel in 1600 as part of the fourth Dutch fleet, commissioned by the Old Company, to reach Southeast Asia. After three years in tropical waters, one side of the ship's hull had started leaking.¹⁰⁴

Unfortunately, most of these references are entries from ship or travel journals that are not very descriptive. Information on how long repairs took, why they took a certain length of time, how many men worked on the repairs, and how much was replanked or sheathed is provided only on rare occasions. It is clear, however, that major ship repairs were all subject to the vagaries of circumstance, as well as available resources and manpower.

One of the most detailed descriptions derives from a ship's journal written on the Indiaman *Zwarte Leeuw*, which sailed to Atjeh and Bantam in 1601 as part of the fifth Dutch expedition to the Indies under the command of Jacob van Heemskerck. On 8 September, *Zwarte Leeuw* sailed from the Bay of Antongil, Madagascar, where it had anchored for 11 days so its sick crew had a chance to recover. Their condition, however, hardly improved because they lacked fresh food. After the ship set sail again, it shaved against a cliff near the island of Sainte-Marie and lost two or three of its pine sheathing boards, which were about a fathom (1.698 m) in length and a palm wide. The crew expected the ship would not start taking on more water than it already had because the damage included only some sheathing boards. Nevertheless, they anchored south of the island in 12 fathoms (20.38 m). The next morning, they realized the ship was taking on more and more water; therefore, the crew began unloading it. On 12 September, two cables were run from the ship to shore and four tide anchors were placed on the ship's weatherboard. After six days, on 18 September, they started heaving stones in order to heel the ship over. Heavy materials, such as stone, were stashed against one side of the ship on its deck to tilt the ship. Once heeled over, the ship's hull could be inspected and repaired. It took the crew three days to get the ship's keel out of the water.¹⁰⁵ The damage turned out to be located at the forward end of the keel; the ship was repaired and righted on the same day. This leak was repaired, but the ship was still taking on water.

On 22 September, it was determined that the ship should be heeled over on its port side and, to avoid taking any risks, they used the large ship's boat, or sloop, to hold the

bowsprit and the small boat to support the sloop's mast. The latter was also used earlier when heeling the starboard side.¹⁰⁶

On the next day, the crew began to pull the ship over to port by ballasting the sloop and small boat. Around the sloop eight empty water barrels were tightly fastened. On the weatherboard, or windward side, of the ship 17 barrels filled with water were hung in tackles to better balance the ship. The tackles allowed the crew better control of the positioning of the ship. To leeward, they fastened a raft made from the yards and topmasts of the ship, to which they fastened another 13 empty water barrels. This was all done to properly secure the ship.¹⁰⁷

By 27 September, the damaged area was located at the turn of the bilge forward of the mainmast; two pine boards about 8 ft long and planks of the first layer of oak planking were in some places worn through, which the crew, by their own accounts, "stuffed and repaired industriously." Three days later, the crew managed "by God's grace" to straighten the ship and immediately started loading it. On 8 October, the spars and topmasts were set in place, and a day later the sails were hoisted. Finally, on the night of 11 October, the ship set sail again.¹⁰⁸ The actual repair was performed relatively quickly, but it took a month to unload, heel *Zwarte Leeuw* over, and repair the ship. Most of the time was spent unloading and heeling the ship onto its side.

VOC SHIPYARDS IN ASIA

After the establishment of the VOC and, consequently, the foundation of permanent bases in Asia to better organize and control the local Dutch trade, facilities were created for the maintenance and repair of its ships.¹⁰⁹ Ships were repaired, sheathed, and/or replanked in Dutch settlements at Firando (Hirado, Japan), Masulipatnam (Coromandel, India), Johore (Malaysia), Sangora and Patani (Siam), and in various places in the Moluccas (Indonesia), such as Ambon, Banda, Batjan, Ternate, and Japara on the northeastern coast of Java, Bantam in the northwest, and the islands north of Batavia.¹¹⁰

Having permanently well-equipped shipyards in the Indies certainly facilitated and sped up the maintenance and repair of Dutch ships. A letter from an Englishman working for the East India Company, written after having observed and trying to predict Dutch activities in the Strait of Malacca, provides some information on how little time the VOC shipyards needed to sheathe their ships. In February 1615, Lucas Autheunis wrote to Sir Thomas Roe in Masulipatnam that "the Dutch in Jaccatra [Jakarta] sheathed three ships in 35 days, which are in the fleet off Mallacca, being at least 800 tons each. It toucheth our reputation too near that we should not be able to do it there as well as they; for although they have continued here this twelve year they never sheathed ship, to take away all occasion whereby they might eat upon them."¹¹¹ The three ships being doubled at this time were *Rotterdam*, *Zon*, and *Maan*.¹¹² *Rotterdam* was indeed a large ship of about 800 tons, but *Zon* and *Maan* were only 400 tons each.¹¹³ These were part of a fleet of 12 ships and a yacht that had sailed to the Indies in 1612 under the command of Adriaen Martenszoon Block.¹¹⁴ *Zon* and *Maan* were brand-new, and *Rotterdam* had been extensively renovated before it left Dutch waters.¹¹⁵ The three ships had been under way for three and a half years when they were brought into the Batavia shipyard to be doubled and probably were in desperate need of maintenance. Although it took 35 days to entirely sheathe the three ships, it is not known how many workmen and how much material were needed or used. The previous discussion has, however, demonstrated that Autheunis slightly exag-

gerated the size of the three ships and was obviously not fully aware of Dutch activities, as they *had* sheathed and replanked ships in Asia prior to 1615.

From 1614 onward, after Jan Pieterszoon Coen's proclamation to sheathe all VOC ships in Batavia, the islands nearby were used as shipyards and repair stations. The sheltered anchorage of Batavia was probably the safest and most tranquil bay in Southeast Asia. A great advantage of the bay was that it was accessible to ships during both monsoon seasons. The shallow waters of the harbor were not suitable to heel ships over, however.¹¹⁶

Batavia's insurmountable drawback was its location near the mouth of the Ciliwung River, because alluvial deposits made the bay too shallow to allow ships to get close to shore to be heeled over to be careened, caulked, or doubled.¹¹⁷ In order to heel over ships, a location sheltered from wind and strong currents where water is deep enough to bring ships close to shore is necessary.¹¹⁸ Repairs on ships that did not involve heeling over were usually performed in the Batavia anchorage. For all other repairs, ships were often sent to the Dutch shipyards at the coral islands situated about 14 km north of Batavia. The most important and largest of these islands was Onrust (Unrest), which quickly became and remained an important shipyard in the Indies between 1614 and 1795 (see fig. 2-17).¹¹⁹ Today the name of the island still refers to its days as a shipyard: Pulau Kapal means Ship Island in English. In the seventeenth century, however, it was called Onrust because of working conditions on the island,¹²⁰ since the repair and maintenance of ships provided an overload of work that kept carpenters working around the clock, allowing them no rest. Ships were often sent to Onrust to be doubled.¹²¹ In 1625, for example, Witte Corneliszoon de With mentions in his journal that the ships *Delft* and *Amsterdam* of the Nassau Fleet were sent to Onrust to be doubled in order to prepare both ships for their homeward voyage to Holland a few months later.¹²² In another source, Onrust is referred to specifically as "our doubling place."¹²³ The shipyard of Onrust had only enough space for three ships to be worked on at one time.¹²⁴ The shipyard and settlement of Onrust were not fortified and had to be evacuated in time of war. In 1618, the English used such an opportunity to ransack the evacuated island for its shipbuilding supplies. Their booty included 8 cannon (which were lying in the water), 120 small and large anchors, 200 hewn oak beams (*swalpen*), a consignment of tropical wood, 2 hawsers, a 20-oar galley, the yacht *Halve Maan*, and a Javanese junk.¹²⁵

ANCHORAGES

Even though permanent shipyards were established in the Indies after 1602, in case of emergency, ships were still repaired or doubled at nearby and accessible anchorages. Near Sierra Leone, for example, a Spanish sugar-prince, captured and renamed *Windhond*, was set ashore to be doubled on 12 August 1623.¹²⁶ This small Spanish ship was taken together with three barques on 4 June 1623 by a Dutch fleet of 11 vessels under command of Admiral Jacques L'Hermite and Vice-Admiral Huygen Schapendam.¹²⁷ Three and a half months earlier, these Dutch ships, better known as the Nassau Fleet, had set sail from Holland with 1,637 men aboard to circumnavigate the world and were instructed to attack the Spanish strongholds on the western coast of South America.¹²⁸ The Dutch ships of this fleet were *Amsterdam* (800 tons), *Delft* (800 tons), *Oranje* (700 tons), *Hollandia* (600 tons), *Eendracht* (600 tons), *Mauritius* (560 tons), and the yachts *Arend* (400 tons), *Koning David* (360 tons), *Hoop* (260 tons), *Griffioen* (320 tons), and *Windhond* (60 tons).¹²⁹ The last turned out to be an albatross around the fleet's neck and even needed

to be towed for several days in order not to lose sight of it. In June 1623, the slow-sailing *Windhond* was sent back to Holland with two of the Spanish barques, all loaded with sugar. They were escorted by a Dutch warship from the Amsterdam Admiralty, *Overijssel*, which had met the fleet on 12 June in Safia (modern-day Morocco, south of Cape Cantin). The remaining Spanish barque was named *Pinksterbloem*, and the small Spanish ship took *Windhond*'s place and name. The Nassau Fleet was now 12 ships strong.¹³⁰

The new *Windhond*, still referred to as a yacht, was also causing problems, as its worm-riddled hull was taking on so much water that its crew could hardly keep it afloat. It was anchored at the Sierra Leone River to be repaired.¹³¹ Crews from all ships of the fleet participated; from each ship two carpenters were sent to help, and their crews chopped down trees in the forest and sawed the planks for the doubling. The larger ships were instructed to provide 30 sheathing boards, and the smaller ships provided supplies in proportion.¹³²

The carpenters could not reach the keel because of a high water level that did not drop as anticipated during the last quarter of the moon. At the same time, they could not get the yacht afloat again, as the water level was too low to do so. It took five days to heel over *Windhond* alongside the *Griffioen*, which was used as its tow ship. The heavy tackles used to heel over *Windhond* consisted of blocks fastened to the top of its mast, and the lower blocks of these tackles were fastened to *Griffioen*.¹³³ Generally, if other ships were present when a ship needed to be sheathed or replanked, they assisted in heeling the ship over to make the work easier.

The sea remained too rough to repair the severely leaking ship, and it eventually was sailed into another bay where the entire procedure had to be started again. There, the carpenters were finally able to reach the ship's keel. On 26 August, with more or less 24 carpenters at work, *Windhond* was finally sheathed. Consequently, a series of uncorrelated events complicated matters even further. One day after the ship was sheathed, its mast cracked as a result of too much pressure from the tackles. Another ship in the fleet, *Mauritius*, nearly sank because the crew had heeled it over but had forgotten to seal the ship's scupper holes. By the time they discovered the omission, *Mauritius* had already taken on 7 to 8 ft (1.98 to 2.27 m) of water.¹³⁴

While *Windhond* was being doubled, the other ships were careened and cleaned. A number of deaths, bad weather, and heavy rainfall prevented the fleet from continuing its journey. Finally, after three weeks, on 4 September 1623, the fleet once again set sail.¹³⁵

The fleet's journal states that *Windhond*'s carpenters managed to double its hull in one day. However, this probably refers to resheathing the ship only, not to replacing its hull planking. Elsewhere, the journal specifically mentions that the larger ships in the fleet had to donate collectively 30 *delen*—pine sheathing boards, *not* hull planks—to accomplish this.¹³⁶

In this particular case, there were enough assistance and supplies to repair *Windhond*, but not every ship was in such an advantageous position. The crew of *Hollandia*, for example, refused to unload its cargo and double its hull planking at Mauritius in 1611, despite specific instructions to do so at their port of departure (Batavia) and to have their companion ship, *Middelburg*, assist. Evidently *Hollandia* was not watertight when it set sail from Batavia, and its clove cargo was moist and hot when it was loaded. The cargo's temperature continued to rise until the ship caught fire near the Azores.¹³⁷ In order to save the ship, the cargo was thrown overboard; the financial loss of cargo was later tallied to be 70,000 thalers (140,000 guilders—roughly 2 guilders per thaler).¹³⁸

Hollandia's skipper, Piet Heyn, who later became famous for capturing the Spanish treasure fleet at Cuba, did manage to sail the ship safely back to the Netherlands, even though there was an acute shortage of provisions and water, in addition to a high mortality rate and an enfeebled crew.¹³⁹ There were probably too many sick and too few healthy men to carry out the doubling of *Hollandia* in Mauritius.

The island of Mauritius was a location that quickly became well known as a good refuge en route for repairs and a post for activities in the Southern Hemisphere. It was uninhabited and had good resources, such as wood for shipbuilding and provisions for the crew. The first Dutch to set foot on the island were Wybrant Warwijck and his men. Warwijck named the island after Dutch viceroy and prince of Orange, Maurice van Nassau.¹⁴⁰ Mauritius was a fertile haven with an abundance of fruits (mainly coconut), turtles, fish, and birds, such as pigeons and dodos.¹⁴¹ Warwijck and his men discovered the island on 17 September 1598 and anchored their five ships, *Amsterdam*, *Zeeland*, *Gelderland*, *Utrecht*, and *Friesland*, in its waters for weeks. Ashore, they foraged for anything edible, the sick were given a chance to recover, and some huts were constructed. Interestingly, the carpenters even built a sloop on the island (fig. 6-3). The island was used mainly as an occasional staging post or shipyard in the years thereafter.

On 31 March 1606, for example, *Dordrecht* started leaking on its homebound voyage because some oak planks of its outer layer of hull planking had washed away. The crew had no other option than to anchor in Mauritius for repairs along with the other ships in its fleet. While *Dordrecht* was partially replanked in Mauritius, *Hollandia* was given a new transom. The resources of wood in Mauritius are stressed in the fleet's journal, and



FIGURE 6-3. The Dutch discovery of the island Mauritius by Warwijck and his men in September 1598. From Commelin, "Waerachtigh verhael van de Schipvaerd op Oost-Indien gedaen by de acht Schepen in den jare 1598," between pages 4 and 5.

while both ships were being repaired, the crews of the other ships kept busy chopping trees and forging iron. Apparently, tens of thousands of trees of all kinds were cut down for the maintenance of the ships and construction of warehouses and used as firewood to make charcoal and to feed the furnaces of two smithies set up to forge ironwork, large numbers of iron bolts, and 20,000 nails.¹⁴²

In the years after the Dutch discovery of Mauritius, they planted fruit trees and left animals, such as pigs, deer, and goats, on the island to ensure future provisions.¹⁴³ These trees and animals were brought by ship from Madagascar and Bantam.¹⁴⁴ In the 1630s, the VOC finally founded a permanent post on the island to prevent the French or English from settling it.

WOOD RESOURCES AND COSTS OF REPLANKING/SHEATHING IN ASIA

It was expensive to add extra layers of planking to a ship's hull. The cost depended mainly on the location of the shipyard, the local price of resources, and availability of craftsmen. According to Coen, the VOC shipyard in Japan charged high prices for redoubling a ship's hull. In a 1627 letter he complains about the significant outlay of 30,000 guilders for the doubling and repairs of two ships in Japan. It is not known whether he was referring to pine sheathing or the replanking of the outer layer of the hull planking.¹⁴⁵ Coen may have expressed discontent to protect his centralized power and control over the company's financial assets. It is clear he did not have his way, as too many ships needed maintaining, and the chronic shortage of wood, carpenters, and sawyers left him no other choice but to send ships elsewhere, including Japan, to be sheathed and/or replanked.¹⁴⁶

It is known from extracts of the daily journal kept in Batavia castle, which holds information on incoming and outgoing ships and on events occurring in the Dutch Indies, that large quantities of wood were needed to construct buildings and refit ships.¹⁴⁷ The VOC in the Indies, however, had to contend with a continuous lack of wood. Although Southeast Asia had plenty of forested areas, they were not always easily accessible to the VOC due to hostilities between the VOC and local rulers. Java, for example, had plenty of timber, but cutting trees there and on nearby islands was a dangerous matter for the Dutch and only possible under protection by armed escorts.¹⁴⁸ The initially congenial relationship between the Dutch and local rulers became strained when the former began establishing a permanent presence on the island. Thereafter, the relationship was characterized by intermittent armed conflicts and lingering wars.

Wood was occasionally imported from Mataram (southern Java, the area around modern-day Yogyakarta), but at great expense, and was not a very dependable source due to tensions between the VOC and the Mataram sultanate. In 1622, the sultanate closed its harbors to the VOC, and timber from Mataram became off-limits for the Dutch. In the same period, similar circumstances cut off the timber supply from Japara in northeastern Java. A document from 1622 describes that the Dutch previously procured large amounts of planks, deck beams, gun carriages, beams, wheels and spokes, futtocks, and all sorts of timber from Japara to construct ships, but by then the place had become inaccessible due to hostilities. They were forced to get their timber elsewhere.¹⁴⁹

A letter from Batavia dating to 27 December 1634 reports the necessity of timber for the ships and boats, such as masts/spars, hewn oak beams, and in particular good pine planking for sheathing, because no quality wood for shipbuilding is found in the Indies,

except teak, which costs 10 times as much as pine from Holland.¹⁵⁰ They also report that Dutch shipyards near Batavia consume large quantities of *baye* wood, which is not very rot resistant and is available only in small lengths of about 14 ft (4.27 m) and 9 thumbs (0.229 m) wide.¹⁵¹ The cost of 100 planks was between 33 and 36 eight reales (66 and 72 guilders—approximately 2 guilders per eight reales) and did not last for longer than six months, which resulted in a loss of nails and labor.¹⁵² Nineteen years earlier, in 1615, Jan Pieterszoon Coen had already suggested that it would be better to use complete planks (as the VOC shipyards in Holland did) and not to use planks sawn in smaller lengths.¹⁵³

When wood was available, its price could be absurdly high, particularly in times of war, which more often than not was the case. A complaint from the Dutch in Ambon in the early 1620s relates that 300 reales (approximately 75 guilders) had to be paid to sheathe one strake of a *corracorra*, a local rowing vessel, and elaborates that, with such prices, it may be better to have ships sheathed in the kingdom of Spain.¹⁵⁴

A potential timber supply was situated on the islands of Bessy and Sebessy, located west of Java. Because they were uninhabited, the company took possession of them in 1624 to prevent other nations from requisitioning and exploiting their resources.¹⁵⁵

Nevertheless, the VOC shipyards of Onrust and the other nearby islands remained dependent upon major supplies such as masts and spars, ropes, nails, iron, lead, resin, pitch, tar, and carpentry tools from the Netherlands until the bankruptcy of the VOC in 1795.¹⁵⁶ Ships arriving in Batavia from the Netherlands were instructed to put their surplus at the shipyards' disposal.¹⁵⁷

CONCLUSION

In the late sixteenth and early seventeenth centuries, Dutch shipwrights built many large merchantmen with a double layer of thick oak hull planking. The VOC especially preferred to build its large East Indiamen with two or more layers of planking. Hull planking was made thicker than called for in the late seventeenth-century Dutch shipbuilding manuscripts of Witsen and Van IJk, as demonstrated by archaeological remains and VOC shipbuilding charters dating to the late sixteenth and early seventeenth centuries. The VOC most likely aimed to construct stronger and heavier ships to better protect the ships' hulls from the damage of heavy seas and results of spending many months at sea away from repair facilities. As Dutch ships were still being built according to a bottom-based tradition in this period, dividing a thicker hull skin into two layers facilitated the bending of heavy oak planks and keeping them in place. Double-hull planking is mentioned frequently in archival documents from the formative years of the VOC, 1602–22. Ships were often purchased and put into service, particularly during the first years after the establishment of the VOC. If such ships were not originally provided with double planking, they had to be fitted with an extra layer of oak planking for the voyage to the Indies. Sometime after the 1650s, however, double planking was no longer employed in the construction of large merchantmen and warships, with the exception of whaling vessels. This corresponds to the time when the bottom-based tradition was replaced with the frame-based construction method in most Dutch shipyards in building large merchantmen and ships of war.

In addition to double-planking the hulls, the VOC often outfitted its ships with an additional layer of pine sheathing to protect the hull from the ravages of teredo worms and

other marine borers. This pine sheathing was fastened with iron nails to the outer layer of hull planking, and the nails were closely spaced to create an iron rust layer to provide additional protection for the hull against marine organisms. This method became a standard worm-protection measure throughout the seventeenth and eighteenth centuries.

Placed between the double planking and also between the hull and the sheathing was a coating consisting of animal hair, sulfur, and a resinous material. Sometimes lead sheathing was also added between the hull planking and sheathing, as in the hulls of *Nassau* and *Mauritius*. Lead was often used during the first few years of the VOC, as revealed by several decrees dating between 1602 and 1606. After 1606, however, its use became less and less common. Apparently, lead sheathing failed to provide the desired protection when the VOC was experimenting with multiple layers of hull planking and sheathing in order to determine the most efficient hull protection for its East Indiamen.

7

TIMBER USED IN THE CONSTRUCTION OF BATAVIA

When the reconstruction of *Batavia* was built in the Netherlands in the 1980s, Nanning Porsius conducted research into the provenance and nature of timber used by the VOC in the early seventeenth century. He wanted to determine what criteria the VOC used to buy such essential resources and what differences in quality were encountered between the contemporaneous timber trading areas.¹

HISTORIC DOCUMENTATION AND TIMBER TRADE

Porsius promptly realized that the scarcity or outright lack of historic sources on the Dutch timber trade immensely complicated his research. Limited VOC archival resources are available for the early seventeenth century. Unfortunately, what VOC archives are preserved do not provide detailed information on where the Chamber of Amsterdam bought its timber when *Batavia* was constructed, what types of timber were used at its shipyards, or how the timber was processed. All six VOC chambers are likely to have kept detailed bookkeeping records, which could have contained useful information on these matters, but hardly any of these records survive today. The only such accounts in existence are the earliest journals of the Chamber of Amsterdam and Chamber of Zeeland up to 1608, the Chamber of Zeeland from 1614 to 1628, and the Chamber of Enkhuizen from 1608 to 1619.² The records of the Chamber of Amsterdam, for example, demonstrate that in the earliest years of the VOC, the purchase of wood was not restricted to any particular supplier.³ A variety of merchants and shipmasters sold timber for shipbuilding in various quantities, ranging from 1 to 400 beams, and at prices from, for example, 40 guilders per 100 pine-sheathing planks to 1 guilder for a single plank.⁴ This variation in price probably depended upon a range of conditions such as quality, size, availability, and bargaining power of the seller.

To help fill the gaps of an otherwise scarce record, Porsius has published his research on the Chamber of Amsterdam's bookkeeping records between February 1603 and January 1604.⁵ These records show that most imported wood came from the Baltic and Scandinavia. Sweden, Denmark, Prussia, and Hamburg were the primary suppliers of pine timber and sheathing, while oak timber came from Danzig (Gdansk) and Königsberg (Kaliningrad) in Poland, Courland (Lithuania), the Memel Territory (Klaipėda region) in East Prussia, Denmark, and Hamburg.⁶ Straight timber for use as planks, sheathing, and beams came from the Baltic, whereas compass timber was transported from the Wesel region in Germany (North Rhine, Westphalia), close to the Dutch border.⁷ The earliest VOC shipbuilding charter, dating to 1603, complies with the preserved bookkeeping records. In this charter, for example, Baltic oak is explicitly listed for the double layer of hull planking, ceiling planking, and all deck planking (see Appendix A).⁸

Furthermore, the minutes from the Gentlemen XVII's meetings indicate that the

Chamber of Amsterdam decided to bypass the intermediary trade in 1611, and a year later, the VOC outfitted a ship destined to sail to Danzig and Königsberg to acquire timber for shipbuilding, including masts, spars, Königsberg planks, hewn oak, and wainscoting. In 1616, they sent another ship to buy mast timber in Danzig. By this time, the Chamber of Amsterdam was using Albert van Elburg as its contact in Danzig for purchase of timber. The Chamber of Zeeland seems to have followed the same procedure when it ordered 200 of the best Königsberg planks and 15 Prussian masts through their contact in Danzig or Königsberg, Tobias Evertssen. The VOC, however, did not continue to bypass the intermediate trade; by 1620, they no longer went out to buy timber themselves and acquired it from the Dutch timber traders.⁹

In addition to material in VOC archives, the first extensive documentation on the wood trade and nature of the timber itself appears in the late seventeenth century. There are many more sources on the wood trade and the nature of the wood itself dating from the late seventeenth century onward.

The auction books of the Zaandam timber market have been preserved from 1655 to 1811, and Cornelis Schillemans has published an in-depth study of them. The auction books inform us that oak timber purchased during this period came primarily from the forests of the Rhine Valley and the river's tributaries. It accounted for 60% of the trade volume of the Zaandam timber market, whereas oak from the Baltic region, mainly Hamburg, accounted for only 13.4%.¹⁰

Other contemporaneous sources, such as the manuscripts of Nicolaes Witsen and Cornelis Van IJk, discuss timber for shipbuilding.¹¹ In addition, Pieter van Dam's work details VOC policy and provides insight into what timber and shipbuilding material the VOC preferred to use in the construction of its ships.¹² As the company's counsel from 1652 to 1706, he was commissioned by its directors in 1693 to write a description of the United East India Company, which he completed in 1701.¹³ From Witsen, Van IJk, and Van Dam, we also learn that oak timber was transported down the Rhine to Westphalia in Germany.

According to Witsen, the fine quality of Rhine oak makes it water resistant and, therefore, suitable for shipbuilding. Compass timber from the Rhine region and straight timbers from Westphalia were highly praised by Witsen's contemporaries. Witsen, however, does not elaborate on timber from the Baltic, with the exception of one remark in which he mentions that the best-quality timbers are oak and pine from Königsberg and pine from Norway.¹⁴

Van IJk, 26 years later than Witsen, also lists Westphalia as a source for oak ship timber in his manuscript but includes Brandenburg, Poland, and other regions of Germany as well. Heavy planks and compass timbers from these areas were utilized in the North Holland shipyards of Amsterdam, Zaandam, Edam, Hoorn, and Enkhuizen.¹⁵

Van Dam had access to the VOC archives for more than half a century, but he does not seem to have used bookkeeping and outfitting documents of the early seventeenth century. His manuscript is actually more in accordance with Van IJk's late seventeenth-century discussion of shipbuilding timber. Van Dam explains that the company built three to four new ships annually that should be made of good and durable timber, preferably *not* from the region directly north of the Rhine. He believed oak from this region to be of poor quality and unsuitable for shipbuilding. Here, Van Dam adds that wood from Munster, purchased on the timber market of Deventer, is much more preferable as it

lasts longer, even though it is less flexible than Rhine wood. Furthermore, the Chamber of Amsterdam made it a practice to acquire Munster wood from the Deventer market. In addition, the shipyard of the Chamber of Amsterdam used timber from Berlin or Silesia in eastern Germany and Poland for the assembly of ships' keels. Compass timber was imported mainly from the Weser and surrounding regions.¹⁶

Van Dam continues that timber from the Rhine region was suitable to use for shipbuilding if it was not in contact with seawater, as, for example, heavy deck beams, deck planking, and other timbers related to the decks, but only if no other wood was available. He also adds that wood from the Rhine region was very flexible, a feature that allows it to be bent easily and to be used for strongly curved timber, such as wales in the bow area. He explains that the poor quality of Rhine timber is a direct result of the trees generally being felled here in summer. Furthermore, planking from Hamburg was the preferred timber shipped to the company's shipyards in the Indies, such as Onrust, probably for maintenance and repairs.¹⁷ Van Dam probably provides the characteristics from the late seventeenth- to the early eighteenth-century era in which he compiled his manuscript, which may not necessarily reflect the company's preferences for timber over its entire 193-year existence. At the time of his writing, for example, the shipyard of the Amsterdam Chamber had problems with oak timber from Rhine forests, which did *not* provide satisfactory results in ship construction.

Despite their limitations, the manuscripts of Witsen, Van IJk, and Van Dam provide a general overview of shipbuilding timbers and their provenance, mainly Germany (Rhine, Elbe, and Weser areas), Scandinavia, Silesia, and the Baltic Sea region in the late seventeenth century. As noted, this overview may not be representative for the entire seventeenth century due to the absence of detailed sources from the early part of the century. Furthermore, the few bookkeeping records and shipbuilding charters of the VOC in the early seventeenth century indicate that most oak shipbuilding timber came from the Baltic Sea and pine came mainly from Scandinavia. There appears to have been a change toward the mid-seventeenth century, when the main source for oak timber shifts from the Baltic to Germany.

The study of historic sources is, however, not likely to provide a clear insight into this change; neither will it provide answers to the basic questions asked by Porsius a few decades ago. The archaeological record and examination of ship's timbers, on the other hand, may provide complementary data to better understand the timber trade and the use of timber in VOC's shipyards in the early seventeenth century.

WOOD IDENTIFICATION

Twenty-two *Batavia* timbers have been sampled and analyzed for wood species identification.¹⁸ The results have shown that at least two different genera of wood were used in the construction of the ship; all structural timbers, such as the planking, frames, ceiling planking, treenails, and beams, were made of oak, *Quercus* sp. (fig. 7-1; tables 7-1 and 7-2). The oak is either *Q. robur* (pedunculate oak) or *Q. petraea* (sessile oak); the wood of these two species can be distinguished based on their anatomical characteristics, and both species were identified among *Batavia* timbers.¹⁹ The differences between *Q. robur* and *Q. petraea*, even if minute, are expressed in the distribution pattern of the small tracheids produced during the mid- and late growth season, after the large-diameter tracheids had formed in a ring shape at the beginning of the growth season.²⁰

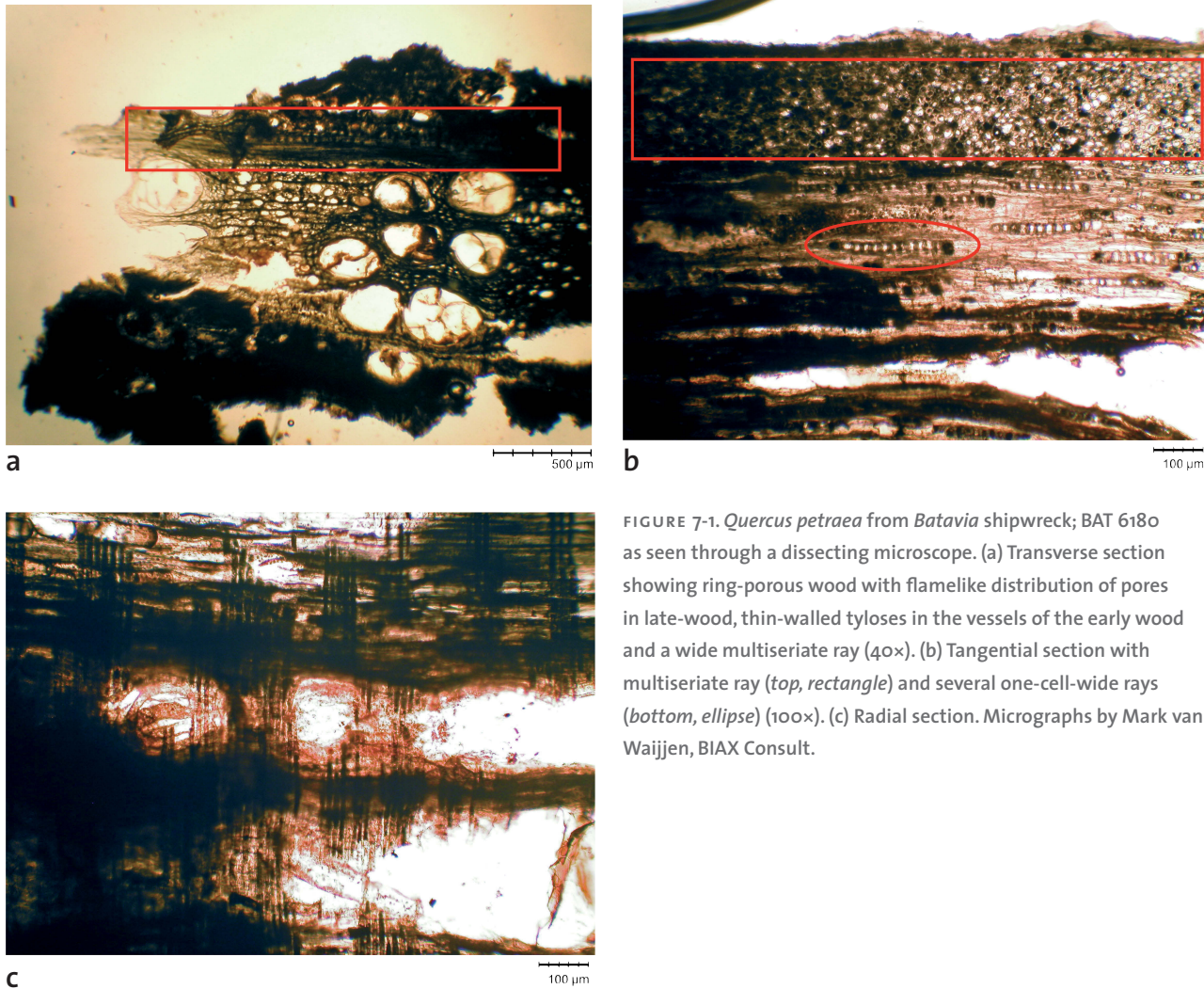


FIGURE 7-1. *Quercus petraea* from *Batavia* shipwreck; BAT 6180 as seen through a dissecting microscope. (a) Transverse section showing ring-porous wood with flamelike distribution of pores in late-wood, thin-walled tyloses in the vessels of the early wood and a wide multiseriate ray (40×). (b) Tangential section with multiseriate ray (top, rectangle) and several one-cell-wide rays (bottom, ellipse) (100×). (c) Radial section. Micrographs by Mark van Waijjen, BIAx Consult.

The sacrificial planking or sheathing of *Batavia*'s hull and the floor on top of its ceiling planking were made of pine, most likely *Pinus sylvestris* (fig. 7-2; table 7-2). Anatomically, no differentiation could be made in the past between *Pinus sylvestris* (Scots pine) and *P. mugo* (mountain pine), but the latter is a dwarf shrub variety not suitable for shipbuilding and therefore unlikely.²¹ However, most recently wood identification of three samples of *Batavia* sheathing confirmed the use of *P. sylvestris*.²²

The wood used for the construction of *Batavia* is consistent with historical records and archaeological evidence from other shipwrecks of Dutch merchantmen, such as Scheurak SO1, *Mauritius*, Christianshavn B&W 2, *Zeewijk*, and *Amsterdam*.²³ In general, shipbuilders preferred oak for the construction of large merchantmen and warships because it is stronger, more durable, and more resistant to rot than other timbers, especially pine. The pine on these Dutch ships was used mainly as sacrificial planking. Large oceangoing vessels destined to sail long distances to tropical regions were built as heavy ships, and shipwrights would employ oak in their entire construction. Van Dam mentions that ships built of pine, or oak below and pine above the waterline, are not good in tropical waters.²⁴

TABLE 7-1. Identification of wood used in *Batavia* timbers

Catalog number	Source of sample	Species
BAT 6063	Ceiling planking, strake 7	<i>Quercus</i> sp.
BAT 6084	Outer layer of hull planking, strake 14	<i>Quercus</i> sp.
BAT 6296	Transom knee, A2	<i>Quercus</i> sp.
BAT 6306	Frame, C34	<i>Quercus</i> sp.
BAT 6311	Frame, C42	<i>Quercus</i> sp.
BAT 6332	Treenail from frame, C35	<i>Quercus</i> sp.
BAT 6356	Upper fashion piece	<i>Quercus</i> sp.
BAT 6358	Transom beam 7	<i>Quercus</i> sp.
BAT 6390	Inner layer of hull planking, strake 4	<i>Quercus</i> sp.
BAT 6422 B	Outer layer of transom planking, strake 7	<i>Quercus</i> sp.
BAT 6444	Fashion piece	<i>Quercus</i> sp.

Note: Identification by Nancy Mills Reid and Ian Godfrey, Western Australian Museum.

TABLE 7-2. Identification of wood used in *Batavia* timbers

Catalog number	Source of sample	Species
BAT 6022	Frame, C3	<i>Quercus petraea</i>
BAT 6068	Inner layer of hull planking, loose fragment	<i>Q. robur</i>
BAT 6150	Sheathing (sacrificial planking)	<i>Pinus sylvestris</i>
BAT 6161	Outer layer of hull planking, strake 1	<i>Q. petraea</i>
BAT 6180	Outer layer of hull planking, strake 4	<i>Q. petraea</i>
BAT 6226	Plank between transom and side ceiling planking	<i>Q. petraea</i>
BAT 6273	Floor on ceiling planking	<i>P. sylvestris</i>
BAT 6375	Inner layer of hull planking, loose fragment	<i>Q. robur</i>
BAT 6404	Inner layer of hull planking, strake 13	<i>Q. robur</i>
BAT 6439	Sternpost cover planking	<i>Quercus</i> sp.
BAT 6441	Sheathing (sacrificial planking)	<i>P. sylvestris</i>

Identification by Caroline Vermeeren and Pauline van Rijn, BIAx, and Nili Liphshitz, Botanical Laboratories of the Institute of Archaeology, Tel Aviv University.

DENDROCHRONOLOGICAL RESEARCH

The *Batavia* timbers provide a unique archaeological resource for dendrochronological examination because exact dates are available for the ship's construction and its sinking. It is known, for example, that the construction of the ship began sometime after the spring of 1626. The Gentlemen XVII commissioned no new construction of Indiamen at its meeting in the summer of 1627 and did not meet in the spring of 1628. On 25 May 1628, however, *Batavia*'s shipwright, Jan Rijcksen, and several administrators were sent to purchase timber for the construction of two new ships, one of which would

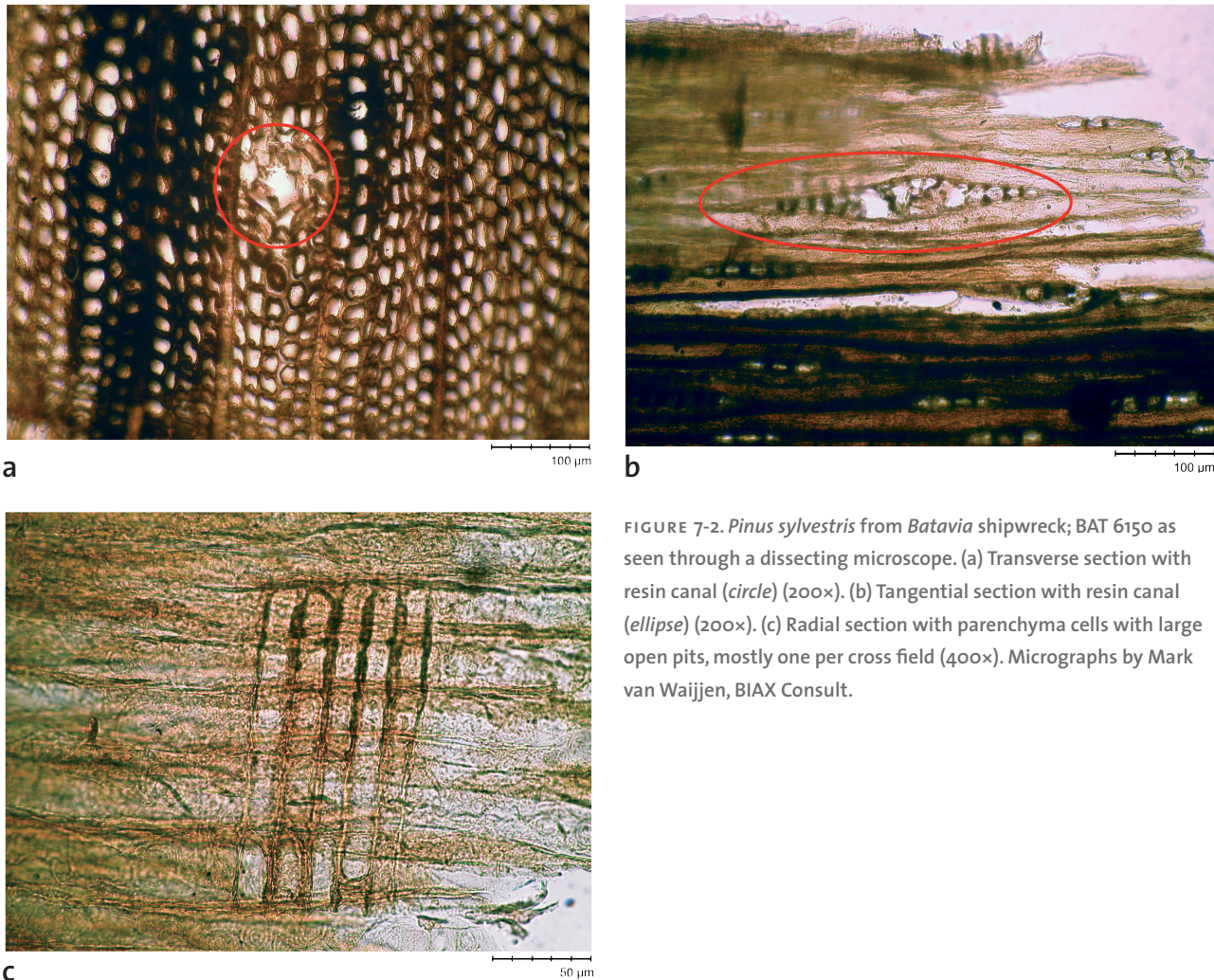


FIGURE 7-2. *Pinus sylvestris* from *Batavia* shipwreck; BAT 6150 as seen through a dissecting microscope. (a) Transverse section with resin canal (*circle*) (200×). (b) Tangential section with resin canal (*ellipse*) (200×). (c) Radial section with parenchyma cells with large open pits, mostly one per cross field (400×). Micrographs by Mark van Waijjen, BIAAX Consult.

be named *Batavia*.²⁵ Whether the construction of both ships was already under way by then is not known. *Batavia* set sail on 28 October 1628 from Texel, bound for the Indies, and was only eight months old at the time of its sinking on 4 June 1629.²⁶ It was practically brand-new, and the crew did not stop and refit on its maiden voyage; therefore, all of the timbers of the archaeological remains must be the timbers of the original construction. This is especially important, for no repairs or maintenance work can possibly confuse the outcome of dendrochronological research, as is often the case with other well-used and repaired wooden hulls.

Six samples were taken for dendrochronological purposes from four planks of *Batavia*'s hull and one plank of the pine sheathing to determine a felling date and provenance of the timber (table 7-3).²⁷ Only a limited number of samples were taken from *Batavia*'s hull because of the destructive nature of the sampling (sawing a strip 6 cm wide from the planks). More samples, however, should be studied to provide a better statistical comparison and more representative data for all structural members of the hull.

Unfortunately, pine sample BAT 6441 and oak sample BAT 6180 were not preserved well enough to be dated, both being riddled with wormholes. The dendrochronological

data from the remaining four oak samples demonstrate the use of oak trees more than 100 years old from the Baltic region for the construction of the ship. More detailed information on the statistical results, reference chronologies, and characteristics of each sample, which includes the number of tree rings, sapwood, and distance to core, can be found in tables 7-3, 7-4, 7-5, and appendix C.

None of the planks submitted for sampling contain any remnants of sapwood. Only heartwood is evident, which means the felling dates of the trees are an unknown number

TABLE 7-3. Dendrochronological results of *Batavia* wood samples

Sample	Felling date	Probability* (%)	Reference chronology
BAT 6068 A	After 1616 +9/-6	99.50	NLARTPo1
BAT 6068 B	After 1612 +9/-6	99.00	NLARTPo1
BAT 6180	Not dated	—	—
BAT 6226	After 1614 +9/-6	99.99	NLARTPo1
BAT 6375	After 1540 +9/-6	99.98%	NLARTPo1
BAT 6441	Not dated	—	—

Source: Hollstein, *Mitteleuropäische Eichenchronologie*, 17–18, 27–33; and Jansma et al., “Historische dendrochronologie in Nederland,” 12.

* Probability or statistical certainty of the match refers to the possibility that the similarity between the sample and the reference chronology is *not* a coincidence. The value is based on the *Gleichlaufigkeit* between the two compared series, also called %PV (percentage of parallel variation).

TABLE 7-4. Dendrochronological results of *Batavia* hull wood, *Quercus* sp.

Sample	Pith	Sapwood	Wood edge	n-rings	First year	Last year	Felling date	t	%P	P	Chronology
BAT 6068 A	—	—	—	116	1484	1599	After 1616 +9/-6	5.2	64.2	0.0050	NLARTPo1
BAT 6068 B	20	—	—	95	1498	1592	After 1612 +9/-6	5.3	67.2	0.0100	NLARTPo1
BAT 6180	—	—	—	87	—	—	Not dated	—	—	—	—
BAT 6226	—	—	—	113	1485	1597	After 1614 +9/-6	4.6	70.4	0.0001	NLARTPo1
BAT 6375	10	—	—	182	1342	1523	After 1540 +9/-6	6.9	63.8	0.0002	NLARTPo1

Source: Elsemieke Hanraets, RING Report Numbers 2007002 and 007014.

TABLE 7-5. Dendrochronological results of *Batavia* hull wood, *Pinus* sp.

Sample	Pith	Sapwood	Wood edge	n-rings	First year	Last year	Felling date	t	%P	P	Chronology
BAT 6441	20	—	—	116	—	—	Not dated	—	—	—	—

Source: Elsemieke Hanraets, RING Report Number 2007014.

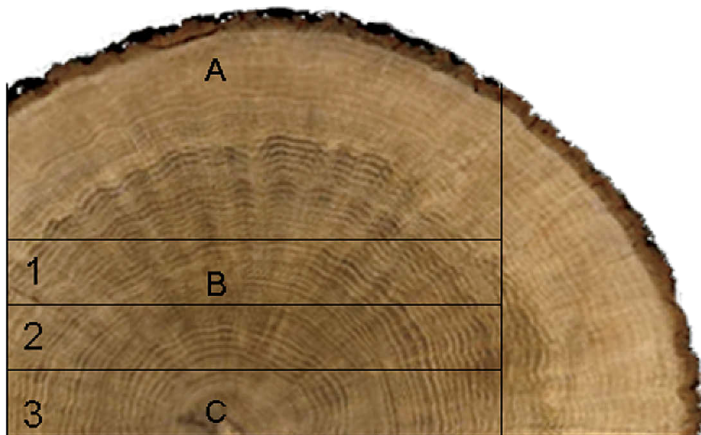


FIGURE 7-3.
Cross section of oak tree with
sapwood (A), heartwood (B),
and pith (C). Photograph by
author.

of years after the last year or most recent tree ring examined in the sample. The samples provide only a *terminus post quem* date.

The dendrochronological investigations of the Renaissance shipwrecks of Christianshavn demonstrate similar results regarding timber use in the ship construction. The absence of sapwood demonstrates that contemporaneous shipbuilders primarily used the heartwood, as it is more resistant to rot than sapwood.²⁸ Sapwood is softer and contains sugars, which make it more subject to insect infestation and decay by microorganisms. Van Dam recommends the use of “good and decent” wood, stripped of all its sapwood. Sapwood is “a pest causing rot like a spreading fire when ships sail in those countries” (he refers to the East Indies and its tropical waters). Van Dam adds that being thrifty with wood is an absolute menace.²⁹

The manufacturing process itself (sawing planks from the timber) easily removed all sapwood and possibly some heartwood growth rings. Planks and sheathing were sawn from halves of logs of approximately the same diameter that were split over their entire length. After the bark and sapwood were removed, the tapering sides were taken off and the timber sawn plain or tangentially into planks (fig. 7-3). All planks of *Batavia* sampled for dendrochronological study were sawn according to this method (fig. 7-4). This manner of sawing can easily be recognized by the pattern of semicircular tree rings in the grain visible at the ends of the planks. Hull plank BAT 6375 could, however, be slightly misleading to the untrained eye, as it is broken into two sections over its pith. Plain- or tangential-sawn timber also tends to cup more over time than quartered or radial-sawn lumber.

PROVENANCE OF TIMBER

The statistical certainty of the analyzed wood samples indicates a near 100% match between the *Batavia* wood and the NLARTPo1 chronology, which ranges from 1115 to 1643 and covers the forests along the banks of the Polish Vistula River (Weichsel).³⁰ This calendar, given its present name in 2006, was referred to in prior publications as Chronology II, SCH1115M, or NLPP.³¹

The research to establish this particular chronology originated in the 1960s when Brongers, Bauch, and Eckstein combined their research efforts.³² Their initial dendrochronological study focused on wood used in works of art. The sample group included

FIGURE 7-4.
Cross sections of
tangentially sawn oak hull
planks from *Batavia* for
dendrochronological study.
Photographs by Patrick Baker,
Western Australian Museum.



151 panels, which form the base of oil paintings, and two wooden sculptures, all of which were made by Dutch and Flemish masters. The majority of the wooden panels were made of radial sections cut from oak trees and contained more than 200 tree rings, in a few cases more than 300.³³ Compiling and matching tree rings gave a chronology from the twelfth to seventeenth centuries, 1140 to 1623, and included paintings made between the fourteenth and the mid-seventeenth centuries.³⁴

The art-historical dendrochronology of these panels established a new oak chronology that did not match any of the existing ones (Chronology II). Most tree-ring series of the panel paintings matched each other so well that a floating chronology of 530 years was created. Initially, Brongers, Bauch, and Eckstein assumed this chronology was typical for the Netherlands. They also thought it unlikely that the Lowlands would have continually imported timber from one particular source for such an extended period of time.³⁵

A similar study established a chronology from English artworks. When the Dutch and English chronologies were compared, they cross-matched.³⁶ This led to the assumption that the wood in the two chronologies came from forests on either side of the English Channel. The provenance and exact time span of the Dutch and English floating chronology were eventually determined a few decades later through a collaborative research effort between the Dendrochronological Laboratory of the Academy of Fine Arts in Warsaw and the Institute for Wood Biology of the University of Hamburg.³⁷ Researchers from both institutions conducted a dendrochronological study on building timbers from churches, historic buildings, art-historical objects, and archaeological material found around Danzig in northern Poland. They could cross-match this wood

with Chronology II.³⁸ Thus, the oak panels of the Dutch painters were not cut from local trees growing on either side of the English Channel but from trees that grew in the Baltic forests along the Vistula River.³⁹ The NLARTPo1 chronology today ranges from 1115 to 1643.⁴⁰

Historical and dendrochronological research suggests an intense wood trade between the Netherlands and Danzig, with timber from the regions around the Vistula River having been shipped to the Netherlands by sea since the fourteenth century.⁴¹ Growth of this Dutch trade with the Baltic resulted in the preeminent position of Dutch merchants in the Baltic by 1600.

Dutch vessels arrived in the Baltic with salt from Portugal and France, herring and construction materials such as tiles and bricks from the Netherlands, wine from France and Germany, textiles from England and India, and exotic goods from the East Indies. These goods were traded for grain and timber from Poland, hemp and flax from Russia, tar from Finland, and copper and iron from Sweden.⁴² The Dutch were at the center of a trade system involving nearly all of northern and western Europe that laid the foundations for, and was inextricably bound to, Dutch primacy in world trade in the seventeenth century.⁴³

The main commercial center for the importation of Baltic timber seems to have shifted over the centuries, first from the harbor town of Bruges to Antwerp and later from Antwerp to Amsterdam.⁴⁴ Timber was shipped into Flanders from the early thirteenth century onward. The earliest archaeological evidence of Baltic oak in this region comes from the fishing village of Raversijde in Flanders, where wooden barrels, possibly used for herring, have been excavated. The timber of the barrel staves was felled in the late fourteenth century.⁴⁵

By the early seventeenth century, Amsterdam had become Europe's main staple market for timber, and the majority of the wood demanded abroad was supplied by Dutch merchants, half of which were from Amsterdam. Most of the wood imported into Amsterdam came from Norway and the Baltic region; to a lesser degree, timber also came from the Rhine area.⁴⁶ Timber from Scandinavia and the Baltic region was shipped in flute ships specifically designed to carry bulk cargoes of this type.⁴⁷ These flutes were fitted with cargo ports in their bow to facilitate the loading of logs and timber.⁴⁸

Bonde, Tyers, and Wazny observe that the dendrochronological data for Baltic wood in western Europe from the fourteenth to the mid-seventeenth centuries usually come from finished products, such as movable objects or planks, not from logs and large beams.⁴⁹ This does not mean that large beams or logs were not transported from the Baltic ports to the Dutch timber markets. To the contrary, wooden logs and lumber were, in general, carried in bulk and processed in the Netherlands into beams or planks manually by sawyers or mechanically by wind-driven sawmills. Fully processed or sawn planks are only sporadically mentioned in the books of the Zaandam timber auctions and make up only 0.65% of the timber trade over the entire period between 1655 and 1714. If planks were imported entirely sawn, they always came from the Baltic or Scandinavia, never from the Rhine region. The importation of sawn wood into the Netherlands must not have been very profitable because of competition with the Dutch sawing industry. The city of Zaandam, for example, had 600 windmills in its heyday during the late seventeenth century, of which more than one-third were for sawing timber.⁵⁰

The contribution of Baltic oak to the Dutch timber market in the late sixteenth and

early seventeenth centuries has evidently been underrated. Historic sources become more abundant after 1650, when the Baltic timber trade had declined and timber from the Vistula forests was no longer transported to the Netherlands. The dendrochronological examination of *Batavia*, plus the earliest VOC documentation in which timber from the Baltic is specifically listed, demonstrates that oak from the Baltic Sea region played an important role at the VOC shipyards in the early seventeenth century.

BALTIC OAKS FOR SHIPBUILDING

Baltic oaks, especially those from the Vistula region, have beautifully straight trunks, and their wood consists of very fine tree rings, which makes the wood easy to work. Dutch and Flemish painters highly prized this straight-grained, smooth wood to paint upon.⁵¹ They would have avoided using panels of soft woods or oaks with knots and other growth aberrations, as these would tend to work, warp, and crack more easily. Wealthy patrons were paying them handsomely to produce masterpieces for family heirlooms that would last for generations. The use, therefore, of high-quality and presumably expensive Baltic oak for such luxury items is not surprising and is completely justifiable economically.⁵²

It is telling that the Dutch, in particular the VOC, used the same high-quality Baltic oak for shipbuilding as the Dutch and Flemish painters did for their artwork. This practice is certainly consistent with the VOC shipbuilding charter of 1603, in which “Eastern planks,” which specifically refers to timber from the Baltic, are listed for the ships’ hull planking.⁵³ It is also consistent with early seventeenth-century bookkeeping records of VOC chambers. VOC shipwrights were building large ships that needed to be strong enough to last through three or four round-trip voyages to Southeast Asia. Obviously, this required good building materials and a high standard of workmanship. The quality of Baltic oak surpassed that of German oaks, which tended to grow more crooked and develop more knots. Even in the late seventeenth century, when discussing German oaks, Witsen makes special mention of the superior quality of Baltic oak.⁵⁴

Regardless of the type of wood, all timber contains some amount of imperfection. Irregularities such as knots or growth aberrations would be problematic in shipbuilding, especially in areas of the hull where shipwrights had to bend heavy planks in complex curves. Dutch shipbuilders, in particular, would remove knots or other imperfections in hull planking and fill in the cavities with graving pieces. Such applications are found in the hull planking of *Batavia*, Christianshavn B&W 2, and Angra C.⁵⁵ The use of high-quality oak and meticulous woodworking techniques in *Batavia*’s hull exemplifies a high standard of workmanship.

THE DISAPPEARANCE OF VISTULA REGION OAKS AFTER 1643

The importation of oak timber from the Vistula forests into northwestern Europe ceased completely after 1643. Attempts to find evidence for the use of this wood in later seventeenth-century artwork or buildings have also failed. Oil paintings after 1643 were produced on panels of oak from the Lowlands and Germany, on tropical hardwoods, or on canvas.⁵⁶

Eckstein, Brongers, and Bauch observed in 1975 that the Vistula River habitat was exploited for its lumber to produce artworks. They also suggested that it could have been “denuded completely for the purpose of building ships.”⁵⁷ The authors offered no evi-

dence or supporting arguments to back up this hypothesis, and their idea was largely disregarded by historical scholars.⁵⁸ Such criticism notwithstanding, the possibility they raise deserves serious examination, especially since the VOC sourced oak timber from the Vistula forests for shipbuilding from its earliest years of existence.

Both Zunde and Wazny have attempted to do just this. Each cites Olechnowitz's work on shipbuilding in the late medieval period when stating that some 4,000 well-grown oaks were needed to build a medium-sized merchantman or oceangoing vessel in the seventeenth century.⁵⁹ This number, however, is too large, especially since Olechnowitz does not refer to merchantmen or oceangoing ships but to warships.⁶⁰ Olechnowitz bases his 4,000-oak requirement on an article in *Mariner's Mirror*, which states that "the average 'seventy-four' of the eighteenth century, varying between 1,600 and 1,900 tons, consumed about 3,000 loads of timber, which was equivalent to stripping sixty acres of oaks a century old."⁶¹ The 74-gun ship, however, was neither medium-sized nor a merchantman but was a large warship. Furthermore, it was built in the eighteenth century.

Henry Adams, shipwright of the 1,370-ton HMS *Agamemnon*, mentions in 1781 that he "needed the felling of 2,000 average oaks to supply 2,000 loads of timber" for the construction of the ship.⁶² One "load" at that time equaled 50 ft³ (1.42 m³), which means that 2,831 m³ of timber went into building the ship's hull. Therefore, approximately 3,000 average oaks would have been required for an eighteenth-century 74-gun ship, not 4,000 as Olechnowitz suggests.⁶³

The dimensions and volume of timber used in such large warships exceed by far those of "medium-sized" oceangoing vessels in the seventeenth century. The reconstruction of the small VOC yacht *Duifje* in 1998, for example, utilized approximately 95 m³ of timber already sawn to its near-finished shape.⁶⁴ This 60-ton yacht was 19.60 m (69 Amsterdam ft) in length from stem to sternpost and 5.45 m (19 Amsterdam ft, 2 thumbs) in beam.⁶⁵ The actual volume of wood used was slightly less, however, because of the taper and snry of the ship's planking and other workings of its timber.⁶⁶ The corresponding volume of flitched logs and sawn planks was approximately 200 tons, which were shipped from Latvia in eleven 40 ft containers.⁶⁷ Using the HMS *Agamemnon* timber ratios, this volume of lumber would have required the felling of some 228 trees.⁶⁸ It must be noted that the *Duifje* reconstruction was made with a single layer of hull planking. The original ship, like other VOC yachts and Indiamen of the early seventeenth century, must have been double-planked, so the volume of wood used in *Duifje*'s reconstruction is significantly less than what the original ship would have required.

Duifje's reconstruction is roughly equivalent in size to a late medieval cog and about one-third the size of an average oceangoing Dutch merchantman from the early seventeenth century. Therefore, depending on the specific size of a ship and the actual size of well-grown trees, the number of trees needed to build a seventeenth-century oceangoing merchantman is many hundreds, perhaps even 1,000, but not nearly 4,000. Nevertheless, this still represents an annual felling of at least 700,000 trees to supply Dutch shipyards, a phenomenal number.⁶⁹ It is certainly possible that the Dutch shipbuilding industry played a significant role in the deforestation of the Vistula River area by 1643. A similar situation occurred in the upper reaches of the Daugava River basin in the Gulf of Riga in Latvia, which was exhausted of its timber in the second half of the seventeenth century.⁷⁰

In support of a historical cause for termination of the use of oak from the Vistula region, Bauch et al. point to the Thirty Years War and the subsequent decline in trade

FIGURE 7-5.

Average number of ships sailing through the Danish Sound per decade from 1605 to 1715. After Lindblad, “Nederland en de Oostzee, 1600–1850,” 15 (graph 1).



between northwestern Europe and the Baltic. They assert that the ensuing Second Swedish-Polish War from 1655 to 1660 caused a total breakdown of the European trade with the Vistula region, including the Danzig timber trade.⁷¹ As a result, the Riga region became a more prominent timber market in the Baltic.⁷²

While the overall Dutch trade volume with Danzig did decline, it certainly did not disappear entirely during the seventeenth to nineteenth centuries.⁷³ To the contrary, hundreds of Dutch ships continued to transport fabrics, salt, and herring to Danzig in the late seventeenth century. Moreover, grain and timber were shipped from Danzig well into the nineteenth century.⁷⁴

Danish taxation registers from the seventeenth century demonstrate that the number of Dutch ships sailing through the Danish Sound decreased from 3,400 per annum between 1610 and 1620 to 2,300 between 1640 and 1650, representing a one-third drop in traffic (fig. 7-5). However, the majority of Dutch merchantmen sailing to Baltic harbors before 1640 were between 60 and 200 tons, whereas after 1640 the average size of the ships increased to 200 tons or more. Thus, the actual volume of trade did not necessarily decrease during this particular period.⁷⁵

Even in 1672, when concurrent political conflicts between the Netherlands, England, France, and some German states temporarily obstructed Baltic trade, some 1,200 Dutch ships still sailed through the Danish Sound. Once hostilities ceased, this trade quickly rebounded. In 1680, some 2,000 Dutch ships sailed into the Baltic Sea, a number comparable to the traffic of 1640.⁷⁶ Thus, Dutch trade with the Baltic and Danzig did not collapse entirely, and the collective impact of the Swedish-Polish War, Anglo-Dutch War, and Thirty Years War did not cause permanent damage to the general Dutch trade with the region. Even though no records are available prior to 1650, the amount of timber that the Dutch imported from the Baltic region as a whole increased from 54,000 tons in 1650 to 160,000 tons in 1750 (see table 2-1). Furthermore, the portion of the overall Dutch timber demand supplied by Baltic wood also increased, from 16% to 47%.⁷⁷

DENDROCHRONOLOGY OF ARCHAEOLOGICAL SHIP TIMBERS

The study of the material record of oak use from the Vistula region by the Dutch mainly derives from dendrochronological investigations of hundreds of panel paintings. In fact, large-scale dendrochronological study of archaeological ships' timbers started only recently. The first extensive study on the timber of a Dutch shipwreck is of an early eighteenth-century *ventjager* (a type of fishing vessel) published in 2004. Some 103 wood

samples from this ship were dated, which indicate that it was constructed after 1705 from oak that cross-matched with at least two areas in Germany, one near Hannover and the other east of Liège in Belgium.⁷⁸

A few modest studies of ship timbers, including *Batavia*'s, demonstrate the potential that a comprehensive examination has to answer questions regarding the Dutch timber trade and shipbuilding industry in the late sixteenth and early seventeenth centuries. *Batavia* is not the only example of a Dutch ship constructed with oak from the Vistula region in Poland dating to this time period. Timber from the Scheurrak T24 and Christianshavn B&W 5 shipwrecks cross-matched with the NLARTPo1 chronology as well.⁷⁹ These two seventeenth-century shipwrecks are not large VOC ships like *Batavia*, destined to haul long distances for the intercontinental trade, but nonetheless substantial merchantmen, both possibly flute ships.

The Scheurrak T24 was one of 12 Dutch shipwrecks included in André van Holk's study on hull timber in the 1980s.⁸⁰ The timbers of only 6 of these shipwrecks could be dated and provenanced. The Scheurrak T24 wreck had well-preserved hull remains measuring 26.85 m long and 6.65 m wide on the seabed.⁸¹ From this shipwreck, samples of 12 hull and ceiling planks were dated and cross-matched with the western German, the Schleswig-Holstein or Hamburg, and the Polish NLARTPo1 chronologies.⁸² Samples matching the NLARTPo1 chronology were taken from 1 hull plank (M15, fourth strake) and 2 ceiling planks (M1 and M2); the most recent rings present on the samples date, respectively, to 1536, 1595, and 1537.⁸³ Like those of *Batavia*, no sapwood was present on these particular samples. The Scheurrak T24 ship was probably constructed in the early seventeenth century, based on the use of the bottom-based construction method and associated archaeological finds.⁸⁴ The ship sank in the Waddenzee sometime after 1655, however, as dendrochronological study of hull plank M13 (sixth strake) has clearly demonstrated. This particular sample, originating in western Germany, has sapwood rings preserved, the most recent ring of which dates to 1635, providing a felling date around 1655.⁸⁵ It may not necessarily have come from the ship's original construction, as old or rotten planks were commonly replaced as part of standard maintenance of a ship's hull.

Oak from the Vistula region was also used in the construction of the Dutch-built Christianshavn B&W 5 ship, most likely a *pinasse* or flute dating to the first half of the seventeenth century. Of 10 datable wood samples taken from this ship's hull planking, 3 may match the same Polish oak chronology NLARTPo1 as do *Batavia* and Scheurrak T24. Seven other hull planks from the B&W 5 Christianshavn cross-match best with timber from Lower Saxony in Germany.⁸⁶

The two dendrochronological examinations of Christianshavn B&W 5 and Scheurrak T24 indicate that the majority of their planking came from Germany rather than the Vistula region.⁸⁷ Moreover, timber from the Dutch-built Danish Indiaman Christianshavn B&W 2, *verlanger* Christianshavn B&W 1, and Baltic trader Scheurrak SO1 shipwrecks came mainly from modern-day Germany, probably the forested regions around Lüneberger Heide and Westphalia, including Lower Saxony.⁸⁸ It should be noted as well that the small number of wood samples studied from *Batavia* may not be representative of all its planking or hull timbers. Nevertheless, the dendrochronological studies of *Batavia*, Christianshavn B&W 5, and Scheurrak T24 shipwrecks now securely confirm the use of timber from the Vistula region in Dutch shipbuilding.⁸⁹ More research is needed to

provide additional evidence for the use of this oak in Dutch shipbuilding, particularly at VOC shipyards.⁹⁰

DRYING OR SEASONING OF TIMBER

Ideally, wood has to be seasoned or dried before it is used in order to extract the tree's natural sap and prevent any deformation or rot. It is unknown whether the VOC required its wood to be dried before use on ships. *Batavia's* timbers are a unique archaeological record that could provide evidence on such a matter, as it is known exactly when the ship was built. Unfortunately, the dendrochronological research of the *Batavia* timbers did not provide a conclusive felling date of the wood because sapwood was not present.

When wood is dried, it becomes lighter, stiffer, and significantly stronger and shrinks slightly. The bending of hull planking for a ship's bottom, however, is an intense process in which heat is applied over an open fire or steam is used to facilitate the bending, a process that extracts a substantial amount of moisture from the timber's surface. If timbers have been dried properly, the process of bending becomes more difficult—even when timbers are purposely wetted during the bending process—and causes the wood to crack. For the construction of the replica of the VOC-yacht *Duifje* in Western Australia, shipwrights purposely used green wood for the ship's bottom. Contrary to the general expectation, this has not caused unusual problems since its construction in 1997.⁹¹ Conversely, the use of dried timber below the waterline is likely to cause serious problems. When the shipwrights assemble the bottom planking, they close the seams as much as possible and subsequently caulk them well. After the ship is launched, the planks swell due to immersion in seawater; this causes enormous stress on the fastenings. When dried, the planks have no place to go but to force themselves off the framing, causing the seams to split open, ultimately resulting in serious leaks.

Bill Leonard, shipwright of the *Duifje*, explains that shipwrights of large wooden vessels differentiated between timber that should be dry and timber that should be damp, with a moisture content in excess of 30%. The availability of resources and other restrictions, however, also influence the construction process, and often shipwrights will simply have to work with what their particular circumstances allow. This applied to the shipwrights who constructed the *Duifje* in the late twentieth century as much as it did for those who worked at the VOC shipyards in the sixteenth and seventeenth centuries.⁹² Furthermore, there is simply no need for dry timber with less than 12% humidity in traditional shipbuilding, and drying large timbers is not practical because of the hygroscopic nature of wood (it absorbs and exudes moisture). It is evident that the climate of northern Europe is generally wet and ships spent their working lives in an even wetter environment.

Traditional shipwrights are aware that some timbers need to be drier than others. Bill Leonard explained that he would prefer to install well-seasoned, dry hanging and lodging knees if available. The structural integrity of knees is important, for if they stop working, they will twist the ship's hull. Leonard also favors reasonably dry quarter-sawn deck planking because, if kept moist, it will not shrink and hence will keep everything below dry. More important, it would enhance the fore and aft integrity of the ship, making the vessel stiffer.

Both Witsen and Van IJk warn against using wood that is too green and prefer dry wood since it is denser, stronger, and less likely to split.⁹³ What "dry wood" means exactly, or how long wood needs to be dried, is not clear.

Van IJk explained that wood stored in salt water preserves well for many years, as does wood in an exclusively dry environment, but wood subject to alternating dry and wet conditions disintegrates quickly. He recommends that timber in storage should be sawn into planks before the shipbuilding process begins in order to extract excess sapwood.⁹⁴ He does not specify how long before construction the wood should be stored. Witsen elaborates that oak felled in winter is stronger, as it contains less nutrients. He advises to cut crosswise into a tree, about four to five days prior to felling, in order to extract live sap and, hence, dry the wood.⁹⁵

TIMBER PROCESSING IN SHIPBUILDING, CONSTRUCTION, AND ARTWORK

The time allotted to process or dry timber for shipbuilding in the early seventeenth century is not known precisely. It may, therefore, be helpful to look at the drying time for wood in regular construction and artwork. Research of contemporaneous structures in Germany has indicated that 67% of the wood was used within a year of its felling date, 29% within two years, and only 4% after more than two years.⁹⁶ The Dutch probably used a practice similar to that of their German neighbors. Many timbers used in Dutch construction works have deformed or cupped cross sections, confirming this practice.⁹⁷

Similarly, Bauch and Eckstein concluded, after their study of hundreds of oak panel paintings, that the panels were probably dried only after the cutting of the oak trunk, which made it possible to use them rather quickly. Although panel making for oil paintings and ship construction are two very different crafts and do not necessarily have the same quality criteria for wood, some of the practices of the former may shed light on those of the latter. Bauch and Eckstein's research contradicted a widespread, now outdated, opinion that panel wood had to be dried for decades before use and showed that the time between cutting and painting the wood varied from one to several years.⁹⁸ Since oil paints and their primers do not adhere well to damp surfaces, the panels do require a minimum amount of drying time.

The dendrochronological examination of several paintings that are signed and dated has demonstrated an average drying time of between 2 and 8 years before utilization of the panels by painters of the Dutch and Flemish schools in the sixteenth and seventeenth centuries.⁹⁹ The curing or drying period is not consistent or similar throughout the centuries or between different artists. The painters in the Cologne school in the fourteenth and fifteenth centuries, for example, seem to have preferred to dry their wood for a period of about 10 years.¹⁰⁰

If wood for artwork was not dried for a long period and timber for building construction was used soon after the trees were felled, then it is likely that shipbuilding timber was not dried for years either. Since at least the seventeenth century, many accounts stress that dry rot, a common term for brown rot, is the greatest enemy of wood.¹⁰¹ These documents explain that the dry-rot fungus occurs in wood that is not well seasoned or is worked while still damp in a poorly ventilated space.¹⁰² According to Van Beylen, ships built of unsuitable wood completely rotted away within five years, after which time timber could not be reused and was generally burned. There are plenty of examples of ships needing to be pumped out for months during long journeys due to leaks caused by dry rot.¹⁰³

An old measure taken to prevent dry rot was the watering of wood, which replaced sap by, preferably, salt or fresh water. Witsen refers to this practice being used in Italy, where sap was leached out by keeping shipbuilding timber submerged in water for long periods

to make it strong and stiff.¹⁰⁴ In 1657, the VOC bought a large plot of land, the Funen or Keerweer, behind the bastion of Jaap Hannes to build a wind-driven sawmill with a house for the miller and storage sheds. This plot was situated at a floating harbor where timber could be watered for six months before use.¹⁰⁵ Even though it has been published that the VOC watered its wood for six months prior to use, no reference to a specific written document has confirmed such practice for the early seventeenth century.¹⁰⁶ As Bruijn, Gaastra, and Schöffer point out, there was no explicit length of time for this practice at the time that the Gentlemen XVII made decisions on the construction of new ships, but they demonstrate that the VOC did plan to water its ship timber for about six months from the early eighteenth century onward. Timbers were immersed in water from the time they were acquired in the spring to the laying down of the keels in November or December.¹⁰⁷

Such a method of seasoning wood was used in the Netherlands well into the twentieth century.¹⁰⁸ Shipwright Bill Leonard remembers such a practice in Great Britain in the 1950s. Timber would be placed in the ocean at so-called silting points to replace fresh water or sap with salt water. Salt water enhances the wood's durability and additionally reduces the need for large storage facilities. The watering of wood, however, would likely be done for a short period, as timber becomes unsuitable for shipbuilding when waterlogged.¹⁰⁹ Timber was also in such high demand that long periods of watering would not have been realistic.

Surface cracking and some repairs, or graving pieces, of *Batavia's* hull planking suggest the use of green wood, which tends to crack easily. Also, it is unlikely that timber was stored at the shipyard of the Amsterdam Chamber for a long period of time, as Jan Rijcksen was sent to acquire timber for the construction of *Batavia* at the end of May 1628, only five months before it was completed and set sail to the Indies.¹¹⁰

CONCLUSION

Durability of ships in service of the long-distance Dutch trading companies, and later the VOC, and their ability to navigate in difficult conditions are likely to have required timber of particularly high quality. Based on dendrochronological and historic research, the volume of imported Baltic timber, specifically from the Vistula region, must have played an important role at VOC shipyards and those building ships for long-distance trade in the early seventeenth century.

Dutch shipbuilding in general, and the enormous increase in the construction of large oceangoing vessels in the early seventeenth century in particular, likely made a great demand on the Baltic oak forests. The Dutch bottom-based construction method for oceangoing ships, such as large Indiamen, was entirely based on the excessively thick hull composed of two layers of oak hull planking. The structural integrity of ships built by this method was heavily dependent on the ships' hulls, so high-quality, straight-grained oak with few growth defects and knots was essential. The construction of ships with two layers of oak planking was expensive and perhaps made too great a demand on the Baltic oak forests, particularly those of the Vistula region, apparently the source of the best-quality oak.

When the frame-based construction method was adopted in the Netherlands in the late seventeenth century, the planking thickness of the ship's hull had decreased significantly from the double layers used earlier in the century, reducing the need for large quantities of high-quality straight oaks from the Baltic. The frame-based ship's skeleton

became the basic principle of ship construction, so compass timber began to play a much more important role than straight-grained oak at the VOC shipyards. In the late seventeenth century, large quantities of compass timber were imported into the Netherlands from Germany, in particular the Rhine and Wesel regions, as has been recorded by Witsen, Van IJk, Van Dam, and the account books of the Zaandam timber auctions.¹¹¹

Recent dendrochronological study of Dutch and Flemish furniture and sculpture indicates that artists and artisans used oak mainly from the Baltic before 1660, but oak from south and central Germany began to be used more often after this date.¹¹² This trend most likely was a reflection of timber imports for shipbuilding.

8

ANALYSIS OF *BATAVIA*'S HULL AND CONSTRUCTION

Batavia's overall dimensions from the VOC archives indicate that it was a slender vessel with a length-to-beam ratio of 4.4:1. The ship measured 160 Amsterdam ft (45.30 m) in length over its upper deck and 36 Amsterdam ft (10.19 m) in beam.¹ It was stipulated to be built with a height between the top of its keel and its lower deck of 12.5 Amsterdam ft (3.54 m), but then the shipwright, Rijcksen, changed this to 14 Amsterdam ft (3.94 m). This dimension plus the height between the lower and upper decks, 5.25 Amsterdam ft (1.49 m), makes a total structural height of 19.25 Amsterdam ft (5.45 m).² *Batavia*'s hold had a significant depth.

DIMENSIONS OF VOC SHIPS IN THE EARLY SEVENTEENTH CENTURY

According to Witsen, the general rule of thumb for the size of Dutch seventeenth-century ships should be one-fourth the ship's length for the beam and one-tenth for the height:³ 160 by 40 by 16 Amsterdam ft (45.30 by 11.32 by 4.53 m) for *Batavia*, instead of 160 by 36 by 19.25 Amsterdam ft. The proportions of *Batavia* were thus more slender and deeper in comparison to the ideal.

In the early seventeenth century, the overall dimensions of VOC ships deviated from this so-called norm. The VOC shipbuilding charter of 1603 also lists a noteworthy depth for a 130 ft VOC ship. Although this ship is beamier with a breadth of 35 Amsterdam ft (9.90 m), and a length-to-beam ratio of 3.7:1, it is nearly as deep as *Batavia* with a hold of 13 Amsterdam ft (3.68 m) and an upper deck of 5 Amsterdam ft (1.42 m), which tallies to 18 Amsterdam ft (5.10 m). Furthermore, the VOC shipbuilding charter of 1616 lists a 142 ft ship with a beam of 36 Amsterdam ft (10.19 m) and a total hold of 19.25 Amsterdam ft (5.45 m). Its length-to-beam ratio is 3.9:1. The heights of both decks of this ship are the same as *Batavia*'s. These examples illustrate that the VOC ships of the early seventeenth century were—by Dutch standards—actually quite high. Furthermore, they also demonstrate that the length-to-beam ratio of large VOC ships increased steadily between 1603 and 1628, making the ships more slender.

BOTTOM-BASED CONSTRUCTION METHOD

As discussed previously, *Batavia* was assembled using a bottom-based tradition, characteristic of early seventeenth-century Dutch shipbuilding. The bottom of a ship was assembled in a shell-based fashion, and the planks were kept together with temporary wooden cleats, after which the floors were inserted. After the temporary cleats and their nails were removed, the nail holes were plugged with wooden pegs. The rows of nail plugs in the lowest preserved hull planking strakes have provided conclusive evidence for a bottom-based construction method. Although nail plugs have been observed in *Batavia*'s planking only up to preserved hull planking strake 10, it may be assumed that the ship's

bottom was assembled up to strake 12. Nail plugs were found on the interior and exterior surfaces of the inner layer of hull planking and the exterior surface of the outer layer. The nail plugs on the interior of the inner layer were from cleats that kept the planking together, whereas those on the exterior surface were from additional cleats that provided extra reinforcement and those that held the wooden shores bracing the ship's hull during construction. Wooden shores continued to be used once the frames were inserted and the second layer of hull planking was applied, once the hull planking was stabilized. *Batavia*'s first, second, and third futtocks were not fastened to each other, further evidence that the hull was assembled in a bottom-based tradition.⁴

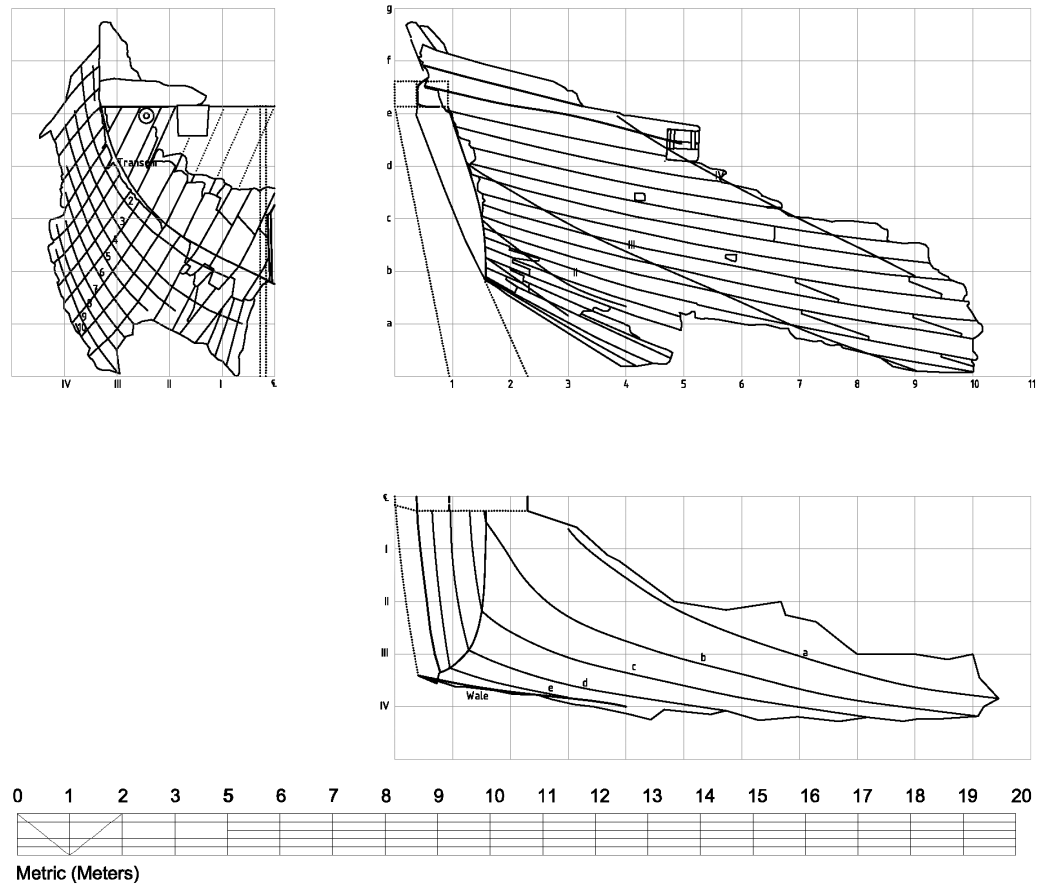
The concept of bottom-based construction is also demonstrated by the multilayered nature of *Batavia*'s planking, which consists of five layers excluding the frames. In this multilayering, starting from outboard to inboard, is included one layer of pine sheathing, two layers of hull planking, one layer of ceiling planking, and one layer of inner floor planking to protect and reinforce the ceiling planking below the lower deck (see fig. 4-22). The frames merely functioned as an extra layer in between, providing lateral stiffening. The remarkable thickness of *Batavia*'s lower hull, with its multiple layers and high-quality oak timber used for planking, indicate that the skin was the starting point for creating a strong, durable, and watertight vessel.

The bottom-based tradition is also demonstrated in *Batavia*'s construction by the discontinuity on the ship's side, where the shell-based bottom hull turns into the frame-based side (fig. 4-22). If reinforcement and shape were obtained by the ship's frames, as in frame-based construction, and not by the bottom planking, such interruption would not be present, as the ship's curvature would be faired more easily. This discontinuity was probably not the result of the change between the double-planked bottom to the single-planked side, for the outer layer of bottom planking was applied in the last stage of construction after the curvature had already been created. In addition, *Batavia*'s lowest wale marks the change between the two construction methods and was the first timber above the bottom added in a plank-on-frame fashion. This wale is a thick plank that is very difficult to bend in a shell-based method. The shipwrights probably waited until the bottom was completed and the frames were installed to add the heavy wale, as it can more easily be forced or bent into shape by pushing it onto the framing.

STERNPOST

Batavia's keel, stem, and sternpost would have been assembled first at the VOC shipyard in Amsterdam. The modest section of sternpost that has survived is the only fragment of the ship's central spine. Its sided dimension tapers from 42 cm at its forward preserved face to 33 cm at its after face, and its preserved molded dimension is 53 cm. According to Witsen, the after end was three-fourths or three-fifths the size of the forward end, which is concomitant with *Batavia*'s sternpost, as three-fourths of 44 cm is 33 cm. *Batavia*'s sternpost may have been 2 cm thicker at its forward end, as the corners have been eroded, making a total of 44 cm or roughly 16.5 Amsterdam thumbs at its forward face. This is, however, slightly thinner than the total 20 Amsterdam thumbs (51 cm) and 18 Amsterdam thumbs (46 cm) listed for the inboard sided dimension in the construction charters for a 130 ft VOC ship in 1603 and 160 ft VOC ship in 1653, respectively. The 1603 charter adds that the sternpost tapers from fore to aft. The VOC shipbuilding charters of 1603 and 1653 list a total length of 27 to 28 Amsterdam ft (7.64 to 7.93 m) for the sternpost.

FIGURE 8-1.
Lines plan of *Batavia*'s
preserved hull section.
The lines were taken off
the exterior of the ship,
thus on the outside
of the hull planking.
Illustration by Cor Emke.



From the waterline markings on *Batavia*'s sternpost one can calculate that 4.10 m are missing from the sternpost's lower end, whereas the upper edge of the wing transom marks the top of the sternpost. When these two factors and the angle of the sternpost are taken into consideration, it is estimated that the linear or vertical height of the sternpost was 25.5 Amsterdam ft (7.20 m). The sided dimension of *Batavia*'s sternpost more or less corresponds with Witsen's suggestion that the thickness (sided) dimension of the sternpost had to be 1 thumb for every 10 ft of the ship's length. For *Batavia*, this would have been 16 Amsterdam thumbs.

The 1603 charter mentions that the angle of the sternpost should be 1 Amsterdam ft for every 7 Amsterdam ft in length. The sternpost here is listed to be 27 or 28 ft in length. This comes to an angle of 8 degrees to the vertical or 98 degrees to the keel (here and elsewhere in this paragraph the angle of the sternpost applies to the aftermost face of the sternpost). Witsen lists 1 ft for every 4 ft of length for the construction of the 134 ft *pinas*, the sternpost being 24.5 ft in length, which tallies to a rake of 104 degrees from the keel. He does say to use a rake of 1 ft for each 6 ft of sternpost length and not to exceed this rule of thumb, as it would be damaging. Witsen stressed that if the sternpost inclined too much, the stern assembly would lose its integrity. *Batavia*'s sternpost as displayed measures 107.5 degrees from the keel, which provides a slightly larger rake toward its after end. This angle is, however, not as steep as the angles provided for the construction of a ship in the English *Treatise on Shipbuilding* dating to the early 1620s. This treatise advises

that the rake of the sternpost should “never recline from the zenith more than an angle [of] 22 [degrees] no[r] less than 18 [degrees].”⁵ *Batavia*'s sternpost raked 17.5 degrees measured from the top of the vertical (corresponding to 107.5 degrees from the keel). It had quite a steep rake, which, according to the English treatise, would not have been considered sufficient. The sternpost rake of the Christianshavn B&W 2 shipwreck was close to that of *Batavia*, 103 degrees from the keel of the aftermost face.⁶

KEEL AND TRANSOM ASSEMBLY

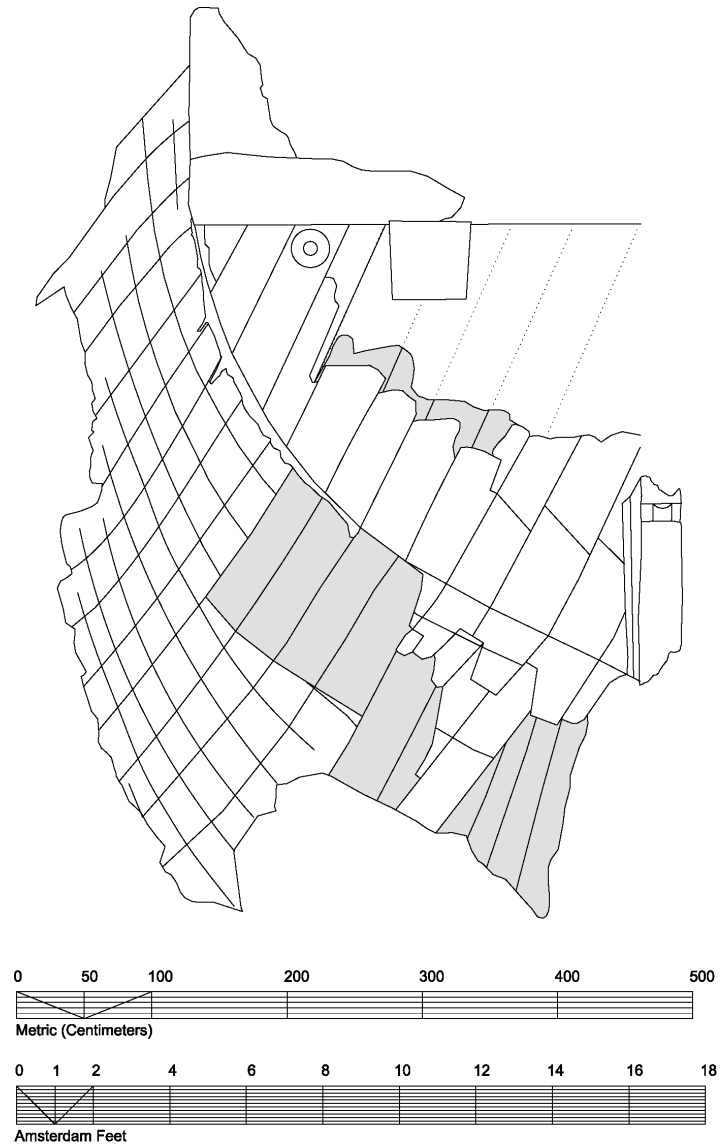
The keel of *Batavia* is not preserved but probably had a double rabbet to accommodate the double layer of hull planking, as seen on the Scheurak SO1, Christianshavn B&W 2, and *Mauritius* wrecks (see fig. 4-14).⁷ Like the ship's sternpost, the keel was probably encased in a layer of oak cover planking and pine sheathing, and it probably had the same sided dimension, 42 cm (16.5 Amsterdam thumbs), as the sternpost's forward face.

After *Batavia*'s keel, stem, and sternpost were erected, the transom timbers were assembled, including the lower fashion piece, transom beams, and wing transom. This assembly was fastened together with many iron bolts that reinforced the dovetail joints of the fashion piece at its after face, in which the wing transom was seated, and the transom beams were slotted into the fashion piece's forward face. The upper fashion piece was added next, bolted to the forward face of the fashion piece over the highest transom beam, BAT 6358. It was erected before the hull planking was applied because the planks are nailed to it and it functioned as the terminus of the aftermost ends of the planking strakes. *Batavia*'s transom was located at a height of 3.80 m above the keel, slightly more than the 13 Amsterdam ft (3.68 m) stipulated in the 1603 charter for a 130 ft ship. The molded and sided dimensions of the transom beams in the 1603 charter are listed as 11 Amsterdam thumbs by 1 Amsterdam ft (both 28.31 cm). *Batavia*'s transom beams have larger maximum dimensions, however, measuring 41 cm sided and molded, which roughly corresponds to 1.5 Amsterdam ft. No height for the transom or dimensions for transom beams are provided in the 1653 charter for the construction of a 160 ft ship. This charter does provide a length of 24 or 25 Amsterdam ft (6.79 or 7.08 m) for the ship's wing transom; the latter measurement corresponds perfectly with *Batavia*'s wing transom (fig. 8-2). Although its preserved length is only about 2.1 m, as reconstructed, the wing transom was 3.54 m long on either side of the sternpost, making its overall length 7.08 m (25 Amsterdam ft).

BOTTOM HULL STRAKES

Batavia's garboard strake and adjacent lowest planking strakes have not survived. On the port side, the remaining hull strakes from the ship's bottom include preserved strakes 1–12, extending from the flat bottom to above the turn of the bilge. The inner layer of hull planking was first assembled in a shell-based method up to strake 12. The plank ends of this layer were scarfed with flat scarfs that were not evenly spread over the ship's lower hull, as demonstrated by the concentration of seven flat scarfs in the forward end of the preserved section. According to the 1603 charter for a large ship, the hull and ceiling were to be made of “eastern” or oak planks that were one-quarter of an Amsterdam ft (7.1 cm) in thickness. It is also specifically mentioned that this thickness depended on the quality of the wood “being soundly flawless.” The planking thickness recommended in the 1603 charter applied to the inner layer of hull planking, as the outer layer, for which

FIGURE 8-2.
Preserved port-side transom
of *Batavia* showing the section
lines of the body plan. Gray-
colored planks represent the
inner layer of hull planking
where the outer layer has
eroded away. Illustration by
author.



no dimensions are listed, is mentioned only at the end of the charter. The 1653 charter for a 160 ft ship lists 4 Amsterdam thumbs (10.3 cm) for the planking thickness up to the first wale. This measurement also applies to the inner layer of planking. *Batavia*'s inner layer of hull planking corresponds more closely with the 1653 charter, as the preserved strakes have a maximum thickness of 9 cm (3.5 Amsterdam thumbs).

FLOORS AND FIRST FUTTOCKS

After Rijcksen and the shipwrights working in the Amsterdam VOC shipyard had assembled *Batavia*'s inner layer of bottom planking, the bottom needed to be reinforced and stabilized before construction could proceed. The rigidity and symmetry of the ship's bottom were not set until installation of the floors and first futtocks, which were shaped and secured to the hull planks with treenails pegged at their exterior ends and most likely wedged at their interior ends. It is not known whether *Batavia*'s floors and first futtocks were fixed in place with a few iron spikes driven from the exterior planking

prior to the insertion of the treenails, as seen, for example, on the Christianshavn B&W 5 shipwreck.⁸ Such iron fasteners provided enough leverage for the floors to stay in place while being treenailed to the planking. Only one possible floor fragment and 11 heads of the first futtocks from *Batavia* have survived.

SECOND FUTTOCKS

The second futtocks were erected next, and their heels, or lower halves, were fastened to the ship's bottom with treenails. Their heads, or upper parts, protruded above the ship's pre-assembled bottom. The ship was presumably constructed by first inserting a set of second futtocks at specific intervals (as known from Witsen, Ralâmb, or archaeological studies, such as that of the Christianshavn B&W 5 shipwreck).⁹ These preset second futtocks were used to define the shape of the hull above the ship's bottom by affixing temporary ribbands or wales to their ends. After these base futtocks were erected and the temporary ribbands or wales added, the remaining second futtocks were installed.

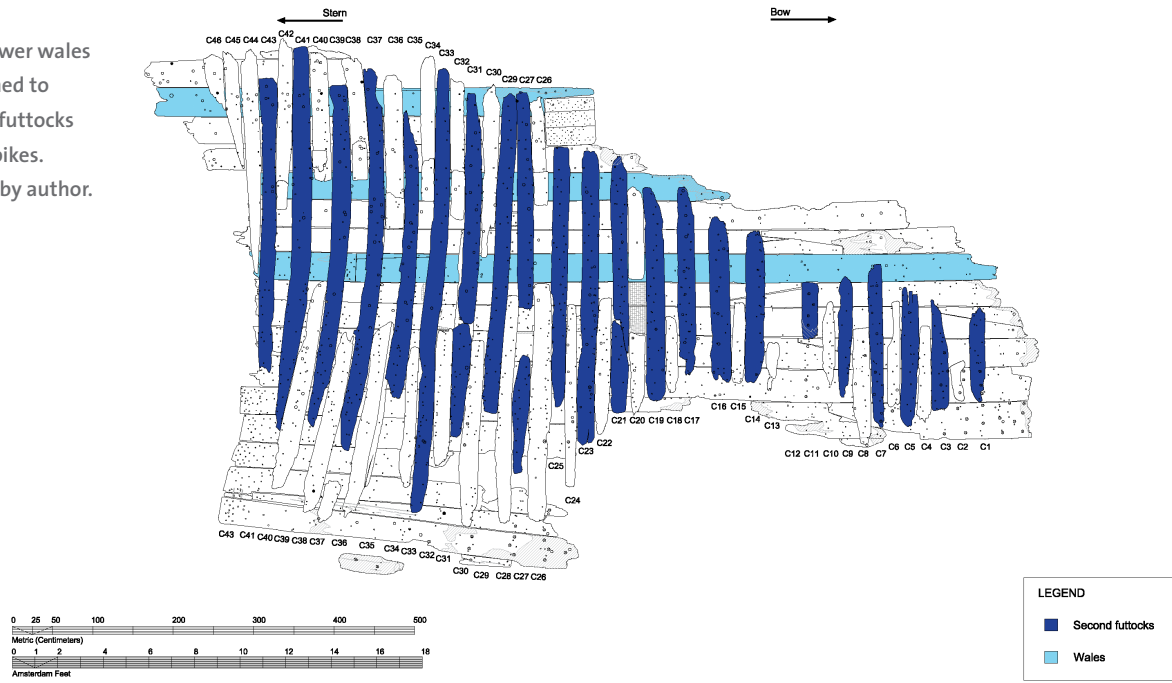
As mentioned previously, *Batavia*'s futtocks had an average sided dimension of 20.7 cm (8 Amsterdam thumbs) and an average molded dimension of 19.1 cm (7.4 Amsterdam thumbs). According to the 1603 charter for a 130 ft VOC ship, the futtocks up to the *scheergangen* (singular, *scheergang*) should be 8 thumbs sided and molded, whereas above the *scheergang* to the upper deck, 7 thumbs, and up to the highest side of the hull, 6 thumbs, depending on the requirements of the ship. This *scheergang* should not be confused with the English term "sheer plank" or "planksheer." In Dutch shipbuilding, it refers to a strake or master ribband extending from the stem to the wing transom that was set up temporarily at the widest breadth of the hull to aid in construction. It defines the sheer of the first deck. Moreover, the placement of the deck beams, gun ports, masts, and hatches would also be marked on the *scheerstrook*, which was reused for the construction of similar ships with all the designated construction marks readily indicated.¹⁰ In *Batavia*, the *scheergang* would have been situated near or at the third wale (strake 19). The sided and molded dimensions of *Batavia*'s lower futtocks up to the third wale do correspond to the 8 Amsterdam thumbs given in the 1603 charter. As only a few third futtocks have survived, it is not known whether the third futtocks or top timbers were of the slightly smaller dimension of 7 Amsterdam thumbs specified in the 1603 charter.

The 1603 charter also described that the ends of the first futtocks staggered 11 Amsterdam thumbs (equals 1 Amsterdam ft, 28.31 cm) and overlapped the floor heads and second futtock heels by 5 Amsterdam ft (1.42 m). It was noted previously that *Batavia*'s futtock ends form an irregularly staggered band, which may be a result of the complicated curvatures and assembly in the stern section. Too few futtock ends have been preserved in the forward section to indicate a more consistently staggered pattern (fig. 8-3). *Batavia*'s frame ends overlap from 1.05 m (3.71 Amsterdam ft) to 1.81 m (6.38 Amsterdam ft), with an average of 1.34 m (4.7 Amsterdam ft). Its average overlapping dimension corresponds roughly to the specifications in the 1603 charter.

CEILING PLANKING

After *Batavia*'s second futtocks were installed, the ceiling planking was added to the bottom hull. This is similar to the construction sequence of the Scheurrak SO1 and Christianshavn B&W 2 ships, where the ceiling planking was added after insertion of

FIGURE 8-3.
Batavia's lower wales
 were fastened to
 the second futtocks
 with iron spikes.
 Illustration by author.

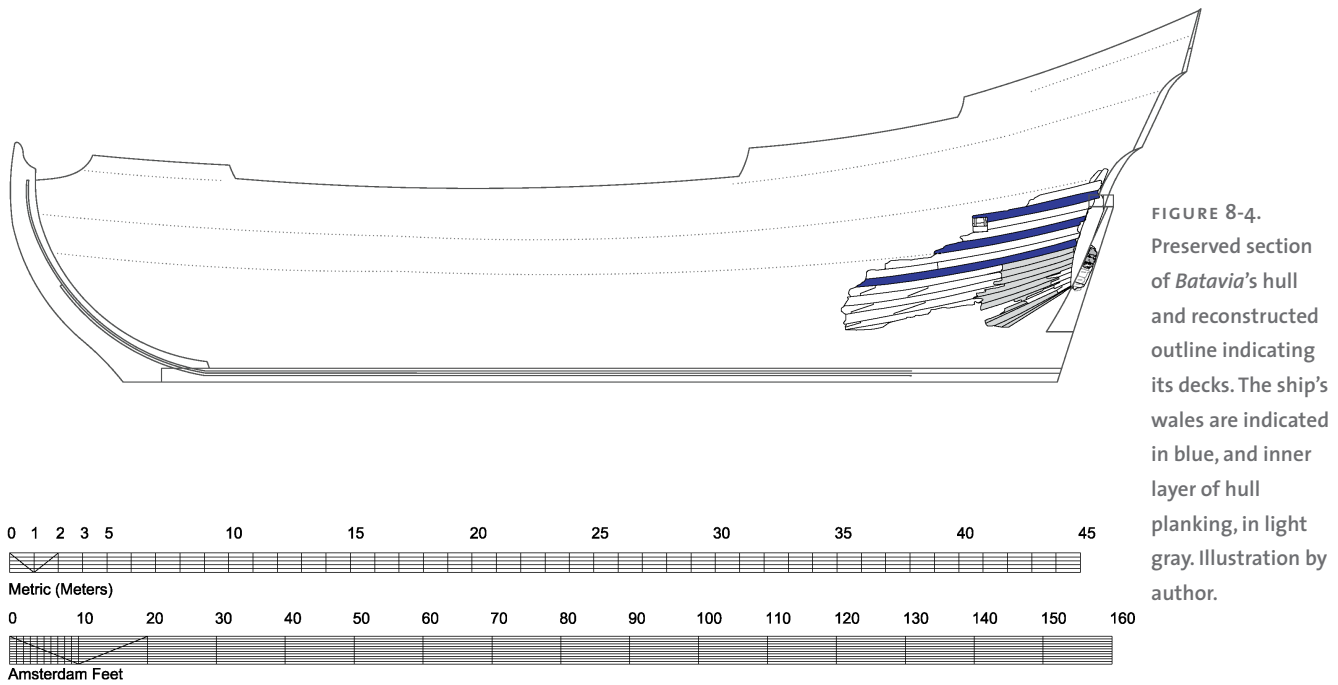


the frames and treenailed through the frames into the inner layer of oak hull planking. Although *Batavia's* preserved ceiling planks were nailed to the frames in the aftermost surviving section of the hull, the ceiling planks on the forward end of this section were treenailed to the planking and frames. Even though ceiling planks have not survived on the forward section, the treenails used to fasten them to the hull are visible on the hull planking and frames (see fig. 4-21, bottom right). These treenails were pegged on their exterior ends and possibly wedged on their interior, as were the treenails used for securing external planks and frames together.

The ceiling planking of *Batavia's* bottom, up to its first wale (strake 13), varied in thickness from 6 to 7.1 cm, with an average of 6.4 cm. This is in agreement with the thickness listed in the 1603 charter, which mentions 0.25 Amsterdam ft for the ceiling planking (7.1 cm), whereas no thickness seems to be provided for this in the 1653 charter. The ceiling planking above ceiling strake 7 is slightly thicker and varies in thickness from 8 to 9 cm, with an average of 8.7 cm. Its thickness corresponds to that of the inner layer of hull planking of the ship's bottom. The ship's bottom ceiling planking was thinner than that of *Batavia's* sides, but it did have an inner floor added to it with a maximum thickness of 3.6 cm (1.4 Amsterdam thumbs).

HULL PLANKING ABOVE THE BOTTOM: WALES, FILLING STRAKES, AND TRANSOM PLANKING

After *Batavia's* bottom hull was assembled, the sides were finished with the plank-on-frame method. All preserved side strakes, from strake 13 up, were nailed onto the second futtocks, and the planking ends joined by vertical flat scarfs (see fig. 4-11). Strakes 13–21 of *Batavia's* preserved port side include three wales (strakes 13, 16, and 19); each wale is separated by two filling strakes (figs. 8-3 and 8-4). These three wales are probably what were considered *spant berghouten* (frame wales), which are essentially main wales or strakes of heavy planking on the side of the ship between the waterline and lower gun deck.¹¹



In the 1603 charter, the 130 ft ship was to be constructed with three frame wales of which the lowest two were to be 14 Amsterdam thumbs wide (36 cm), and their thickness had to correspond to two planks of the hull, whereas the third was supposed to be 1 Amsterdam ft (28.31 cm) wide and 4.5 Amsterdam thumbs (11.6 cm) thick. The three wales of *Batavia* all measure 36 cm in width. The lowest wale measures twice the thickness of the hull planking below and has a maximum thickness of 18 cm (7 Amsterdam thumbs). The second wale may have had the same dimensions, but its original thickness has not survived. The lower two wales, therefore, correspond to the 1603 VOC charter, but the third one does not. It is much wider than 1 Amsterdam ft, and its thickness is much greater than the 4.5 Amsterdam thumbs called for in the charter. It measures 19.3 cm (7.5 Amsterdam thumbs). Although *Batavia*'s third wale is placed at the lower gun deck over the surviving gun port, it can still be considered a frame wale because it was attached to the second futtocks, like the lower wales, and is associated with the lower gun-deck level and not the upper deck (fig. 8-4).

In the VOC charters specific dimensions are also given for the wales “above the gun ports” and “other wale[s].” Strake 19 is technically placed “above the gun ports,” but it also forms the strake through which the gun ports are cut. From this point of view, it is aligned with the gun ports; only the wale above strake 19, which has not been preserved, can truly be considered the “wale above the gun ports.”

By 1653, the charter for a 160 ft ship indicates that the three main wales have the same width (14 Amsterdam thumbs, or 36 cm) and thickness (7 Amsterdam thumbs, or 18 cm). This configuration is much closer to that of the *Batavia* than the dimensions provided in 1603.

The three frame wales, as listed in the VOC charters of the early seventeenth century and seen on *Batavia*, are similar to the three wales below the level of the helm port characteristic of the flute ship.¹² The *Batavia* and VOC charters suggest they were also characteristic of Dutch Indiamen at this time.

Batavia's filling strakes 14, 15, 17, and 18 are situated between *Batavia*'s frame wales

and have an average thickness of 12.5 cm. According to the 1603 and 1653 charters, the lowest filling strake(s) should be 5 Amsterdam thumbs in thickness, which corresponds perfectly with *Batavia*.

The inner layer of transom planking could have been added at any point in the construction of the ship's hull, between the assembly of the ship's bottom to the application of the outer layer of hull planking. It is likely that the transom was planked before or during the planking of the ship's sides, as supported by contemporaneous iconography (see fig. 4-85, left).

DECK TIMBERS

After the ceiling planking was fastened onto the ship's sides, large transom knees were added to reinforce the transom assembly and the aftermost quarters of the hull. The decks were also assembled at this time. Not much of *Batavia*'s lower and upper decks has survived, but the fragmentary deck elements demonstrate that they are similar to the dimensions provided by the charters of 1603 and 1653, with the exception of the shelf clamps and waterways. According to both charters the shelf clamp of the lower deck should have been 14.2 cm in thickness (5.5 Amsterdam thumbs), and the 1603 charter adds that it should be 2 Amsterdam ft (56.62 cm) wide at its narrowest point. *Batavia*'s preserved shelf clamp is much smaller both in width (42.8 cm, or 1.5 Amsterdam ft) and thickness (12 cm, or 4.66 Amsterdam thumbs). The same applies to the preserved waterway, which had a thickness of 10.7 cm, whereas the 1603 and 1653 charters list thicknesses of 7 Amsterdam thumbs (18 cm) and 5.5 Amsterdam thumbs (14.2 cm), respectively.

The 1603 charter specifically mentions that ships had to have riders on the lower and upper decks for each deck beam, whereas 50 years later there were fewer riders, one at every other deck beam. The spacing interval of *Batavia*'s riders is not known, nor is whether every other deck beam was accompanied by a rider. The interval between the riders can be observed from the bolt holes left behind in the frames and planking (frames C30, C27, C24, C23, C22, C17, C16, C14, C11, C7, and the foremost edge of the preserved hull), and their irregular room and space varies from 46 cm to 1.73 m. It must be noted that too little of the hull remains to adequately understand their spacing and frequency, especially since the narrowing at the stern section of the ship may have required a diversion from the rider framing placement used for the rest of the hull. Riders consisted of a floor and a first futtock; the deck hanging knees were part of the rider frame assembly, as they essentially functioned as second rider futtocks.¹³ The preserved bolt holes found in *Batavia*'s hull remains support such a configuration.

The 1603 charter also mentions that all deck beams should be accompanied by knees that have a 4 ft (1.13 m) overlap with the beam ends and ceiling planking. These knees could refer to both lodging and hanging knees. No mention is made for any such dimensions in the 1653 charter. *Batavia*'s deck knees are not well preserved where they overlap the deck beams, and the overlap of the two hanging knees with the ceiling planking is much larger. The two hanging knees recovered from *Batavia*, one to support the lower deck (BAT 6227) and the other for the upper deck (BAT 6130), are preserved to lengths of 1.52 and 1.82 m, respectively (see fig. 4-22). This indicates that the hanging knee of the upper deck spanned almost the entire height between the two decks, which was higher aft due to the raised platform. *Batavia*'s preserved lodging knee separates the two deck

beams by 1.31 m. This is also slightly larger than the distance of 4 ft from one deck beam to another in the ship's hold, as provided by the 1603 charter. Both the 1603 and 1653 charters mention a molded and sided dimension for the lower deck beams of 14 to 15 Amsterdam thumbs (36 to 38.6 cm), but *Batavia's* two beams are not preserved well enough to make a good comparison.

As with the riders, the surviving lower deck pieces are too few and too poorly preserved to make a good comparison of their dimensions, placement, and spacing with those in the charters, and the ship's narrow stern area may have required dimensions and assembly different from that of the rest of the lower deck timbers. The only deck timbers that can be compared to specifications in the 1653 charter are the platform planks, which have a maximum preserved thickness of 7.5 cm (3 Amsterdam thumbs). This dimension is a good match with dimensions in the charter.

SECOND LAYER OF BOTTOM PLANKING

Throughout *Batavia's* hull, the outer layer of planking was nailed to the inner layer with iron spikes, and the planking ends were scarfed together with flat scarfs. This outer layer had the same thickness as the inner layer and was added to the ship's bottom from its keel up to the first wale (strake 13). According to the 1603 charter for the construction of a 130 ft VOC ship, the vessel was covered with oak planks after the hull was built up and the two full decks and quarterdeck were completed. The pegged treenails used to affix *Batavia's* frames to the inner layer of planking confirm that the second layer was attached to the inner layer of hull planking after the frames were inserted. In particular, the pegs on the ends of the inner planking treenails prove that the outer layer of hull planking was applied after the floors and futtocks of the bottom were already installed. Furthermore, *Batavia's* rudder gudgeons must have been installed before the outer layer of planking was nailed to the hull, as the gudgeon ends were fastened to the inner layer of transom planking with iron spikes and were covered by the outer layer of transom planking. The second layer of bottom hull planking was, thus, applied in the last stage of the ship's construction after the gudgeons were hung but before the ship was sheathed with pine boards and payed with hair and a resinous substance. After the outer layer of hull planking was added up to the first wale, the bottom hull had the same thickness as the first waterline wale, which was then no longer distinct as a wale.

PINE SHEATHING

Batavia's bottom hull was sheathed with a layer or two of pine. According to Witsen, a layer of "good" skin was fastened with numerous small nails to ships sailing long distances. This skin was placed on top of a layer of cattle hair and sometimes a layer of copper or lead, measures to keep away the "vermin living off the wood."¹⁴ Van IJk mentioned a 155 ft (44 m) vessel being built for the Indies with pine sheathing, below gun ports, from the bottom to the sides. Elsewhere, he mentions that pine sheathing should be applied from the bottom to the sides, or above the waterline, and from the keel up to the lower wales (main wales).¹⁵ This corresponds with *Batavia*, as the ship was certainly sheathed up to the second wale below the gun ports. No traces of closely set nail holes have been found on the exterior surface of *Batavia's* planking on the strake above the second wale (strake 16). This is much lower than suggested in the 1603 charter, in which

it is mentioned that the hull should be sheathed with pine boards up to the underside of the quarterdeck wale.

CONCLUSION

The dimensions of *Batavia*'s surviving timbers correspond closely to the dimensions provided in the VOC shipbuilding charter of 1653, except for the height of its sternpost. Although some of *Batavia*'s construction details and dimensions also correspond with the charter of 1603, most proportions differ from the ones in this charter. This demonstrates that by 1628, when *Batavia* was built, the VOC shipwrights had moved away from constructional details as described in the earliest VOC shipbuilding charter of 1603.

CONCLUSION

Batavia was clearly the result of dynamic developments in the Dutch shipbuilding industry that occurred in the late sixteenth century. Like the flute for the Baltic trade, India ships and the smaller yachts were introduced for a special purpose, in this case the long-distance trade with Asia, a result of the country's socioeconomic, technological, and political climates at this time. In the 1590s, when the Dutch started sailing to the far corners of the world, these new types of ships had to be designed and constructed for the long-distance voyages to Asia and back.

Despite the relatively limited extent of *Batavia*'s hull available (about 3.5%), this study provides a working hypothesis regarding the shape and construction of the vessel. The construction sequence and design of the ship generally match the guidelines provided by Nicolaes Witsen, the early seventeenth-century VOC shipbuilding charters (in particular the charter of 1653), and the archaeological remains of other, similar ships. Although many questions remain unanswered, *Batavia*'s timbers demonstrate typical Dutch shipbuilding practices of the late sixteenth and early seventeenth centuries and provide new information unknown prior to this study.

Iconography and historical sources inform us that these fully rigged ships had physical features such as a flat transom, fore- and sterncastles, pine sheathing, a deck with gun ports along the side of the hull, and heavy wales girdling the ships' sides to provide longitudinal and transverse strength. With the founding of the VOC in 1602, specific guidelines for its shipwrights were written down in construction charters. These are important documents for the study of Dutch East India ships and yachts, as they demonstrate that the vessels were constructed as heavy ships and had two full decks in the early seventeenth century. The charters were, however, basic instructions for the shipyards of the VOC chambers and do not disclose the details that made Dutch India ships different from other merchant ships and what specific features were considered important on their long voyages to Asia.

Detailed information on VOC shipbuilding was not written down, probably to safeguard the secrets of the trade (as evidenced by the VOC's resistance to colonial shipbuilding and the export of Dutch shipbuilding knowledge). The overall dimensions provided by the VOC charters must have been sufficient for its shipwrights to know what proportional rules to apply, information that was evidently taught through apprenticeship and verbally passed on from generation to generation.

The overall dimensions of Dutch Indiamen and yachts provided in the charters demonstrate that the ships were slender, with their length-to-beam ratio varying from 3.7:1 to 4.5:1 between 1603 and 1628. The vessel had a 4.4:1 length-to-beam ratio, and its hold had a significant depth. When compared to contemporary Dutch standards, the VOC ships were relatively high in the early seventeenth century.

Batavia's hull remains indicate that the Dutch were not building their early Indiamen in a frame-based manner like other countries and assembled their ships with notably thicker hulls than used in later ships. This is consistent with the archaeological evidence for almost all shipwrecks discussed in this book with the exception of VOC yacht *Avondster*, which was a refitted English ship, most likely assembled using a frame-based construction method. The yacht of Willem Barents, merchantman Scheurrak SO1, Dutch East Indiaman *Mauritius*, VOC yacht *Vergulde Draak*, Angra C ship, and Dutch-built Indiaman Christianshavn B&W 2 were all built according to the bottom-based construction method typical for northwestern continental Europe. This type of construction entails the assembly of the keel, endposts, garboard strakes, and bottom planking, which are temporarily fastened with cleats before the framework of the hull is erected. It is likely that the VOC ship *Nassau* (1606) was constructed according to a bottom-based method, but not much information on this ship is available.

The remains of *Batavia* clearly demonstrate that the VOC shipwrights focused primarily on the ship's strength, waterproofing, and provision of the utmost protection against teredo worms and marine organisms. These three characteristics were added to the ship by creating a laminate-type hull consisting of five layers, excluding the frames. Most of the strength was provided by the two layers of oak hull planking, with additional strength added by one or two layers of pine sheathing, the ceiling planking, and the layer of cargo floor planking that protected and reinforced the ceiling planking below the lower deck. The frames mainly functioned as the layer that provided additional lateral stiffening. The unusual thickness of *Batavia*'s bottom hull built up with multiple layers of high-quality oak timber indicates that the skin was the starting point for creating a strong, watertight vessel.

The ship's bottom hull is remarkably thick: 18 cm for the two layers of hull planking alone. These two layers added greater strength to the hull and provided extra waterproofing, as their seams had a slight offset, like overlapping roof shingles.

Double-planked hulls seem to be unique to Dutch ships of exploration, as well as the Indiamen and yachts sailing to the Indies from 1595 to 1654. All wrecks of Dutch ships destined to sail long distances dating to this period, such as the yacht of Willem Barents, *Nassau*, and Dutch East Indiaman *Mauritius*, indicate that they were built with a double layer of oak hull planking. Unlike the Dutch flute and other bulk cargo carriers intended for use in European waters, the Indiamen were built much stronger than was believed to be the case by historians.

The hull remains of late sixteenth- and early seventeenth-century Dutch-built long-distance traders, with the exception of *Vergulde Draak*, all have two layers of hull planking of approximately the same thickness. The use of double planking in certain types of Dutch-built ships was likely to have been directly influenced by the practice of lengthening ships, which occurred in the same period. Lengthened ships, or *verlangers*, were closely related to the development of the flute ship, but the term *verlanger* refers to the process of lengthening a vessel rather than to a specific type of ship. It is known, for example, from the Christianshavn B&W 1 shipwreck that an existing hull being lengthened could be strengthened by adding more planking to the ship's exterior and/or by applying thicker ceiling planking. Lengthened vessels were probably the first examples of Dutch merchant ships with two layers of hull planking. The primary reason for the extra planking was to longitudinally reinforce the hull.

Shipwrights who constructed Holland's first long-distance sailing vessels in 1595 probably followed the example of those building *verlangers* and built large merchantmen with a double layer of thick oak hull planking. Archaeological remains and VOC shipbuilding charters dating to the late sixteenth and early seventeenth centuries demonstrate that hull planking was thicker than called for in the late seventeenth-century Dutch shipbuilding manuscripts of Witsen and Van IJk. Dutch builders faced with the need to build for voyages much longer and farther than anything they knew opted to build much heavier ships at greater costs to meet the new challenges—essentially a conservative approach to protect cargoes, lives, and investments—whereas they were shifting to more inexpensive materials, building techniques, and outfitting costs for ships intended for local trades. As Dutch ships were still being built according to a bottom-based tradition, dividing a thicker hull skin into two layers facilitated the bending of heavy planks and keeping them in place during construction. Two thinner layers of hull planking were probably stronger than one very thick layer and more watertight. Double-hull planking is mentioned often in archival documents from the formative years of the VOC, 1602–22. Standard merchant ships were often purchased and put into service, particularly during the first years after the establishment of the VOC. If such ships were not originally provided with double planking, the company believed it was necessary to fit them with an extra layer of oak planking for the voyage to the Indies.

In addition to double-planking the hulls, the VOC often outfitted its ships with an additional layer of pine sheathing to protect the hull from the ravages of teredo worms. This pine sheathing was affixed to the outer layer of hull planking with iron nails, and the nails were closely spaced to create a layer of iron corrosion (rust) to provide additional protection for the hull against marine organisms. This became a standard worm-protection measure throughout the seventeenth and eighteenth centuries.

The archaeological remains of the VOC ships *Nassau*, *Mauritius*, *Batavia*, *Vergulde Draak*, and *Avondster* and the Dutch-built Danish East Indiaman Christianshavn B&W 2 were all fitted with an additional layer of sacrificial planking or pine sheathing. *Batavia*'s hull was sheathed with pine planking with a maximum thickness of 4 cm, up to at least its fifteenth preserved strake of hull planking. On the exterior surface of strake 14, the ship even had two layers of pine sheathing that were most likely applied to compensate for the 5.5 cm loss of hull thickness above the turn of the bilge (between the ship's bottom and sides). The two layers of pine sheathing obscure the discontinuity in the ship's exterior surface.

In addition to pine sheathing, layers of goat hair were applied to *Batavia*'s hull with a resinous substance, probably tar, on all outboard surfaces of the hull planking (on both inner and outer layers), and some hair was also found on the outboard surfaces of the pine sheathing, to provide extra protection against teredo worms. Such a coating consisting of animal hair, resinous materials, and sulfur was typical for VOC ships. Lead sheathing was sometimes added between the hull planking and sheathing, as in the hulls of *Nassau* and *Mauritius*. Lead use during the first few years of the VOC is revealed by several decrees dating between 1602 and 1606. After 1606, however, it became less and less common. Apparently, lead sheathing failed to provide the desired protection when the VOC was experimenting with multiple layers of hull planking and sacrificial sheathing to determine the most efficient hull protection for its East Indiamen. Or possible weight and maintenance problems drove it out of use.

Externally, *Batavia*'s hull was sheathed with pine boards held in place by closely set iron filling nails, but the ship was also sheathed internally with a pine inner floor nailed to the ceiling planks over wooden laths. This floor extended over the ship's bottom up to the lower deck and had the same thickness as the pine sheathing on the ship's outside surfaces. This floor was probably to protect the ceiling planking from wear by shifting cargoes.

Batavia's bottom hull consisted of layer upon layer upon layer, and even the modest remains of its sternpost demonstrate the application of multiple layers of reinforcement and protection. It was encased in one layer of oak planking, on top of which a layer of pine sheathing was nailed. Between these two layers a thin layer of copper sheets was applied, whereas the outboard surfaces of both layers were covered with hair and tar. Essentially, every technique known or available on the shipyard was applied to the ship's sternpost, and presumably also its keel and stem, to protect it against teredo worms and impact damage, thereby reducing the risk of injury to this vital element. The impact of galvanic corrosion caused by the iron nails to the protective planking and copper sheathing must have been problematic, despite the layers of goat hair in between. The graving pieces and other construction features, such as the attachment of the sternpost's gudgeon to the transom, also indicate that *Batavia*'s shipwrights were meticulous and skilled craftsmen who were very proficient in trying to make the vessel's assembly shipshape and sturdy.

Sometime after the 1650s, however, double-hull planking was no longer employed in the construction of large merchantmen and warships, with the exception of whaling vessels. The *Vergulde Draak* may be the earliest example of a Dutch Indiaman from the seventeenth century with a single layer of oak hull planking.

The construction of large VOC ships like *Batavia* using a bottom-based method and multiple layers of thick oak hull planking must have required vast quantities of high-quality timber. Based on dendrochronological and historical research, the volume of imported Baltic timber, specifically from the Vistula region, played an important role at VOC shipyards and those that were building ships for long-distance trade in the late sixteenth and early seventeenth centuries.

Looking at the excessive timber use in *Batavia*'s multiple-layered hull, it is easy to understand that this type of Dutch shipbuilding, coupled with the enormous increase in the construction of large oceangoing vessels in the early seventeenth century, created a heavy demand upon the Baltic oak forests. Ships built in this fashion required high-quality, straight-grained oak with few growth defects or knots. Thus, the construction of ships with two layers of oak planking was expensive and likely depleted the Baltic oak forests, particularly those of the Vistula region, apparently the source of the best-quality oak.

The abandonment of two-layered oak planking in the construction of VOC ships (and other large merchant vessels) seems to have occurred sometime after the 1650s. It decreased the total planking thickness significantly, reducing the need for high-quality straight oaks from the Baltic. The *Vergulde Draak*, constructed using the bottom-based method but with much thinner hull planking than other VOC ships discussed here, may indicate the start of this trend toward single-layer planking. The discontinuation of double planking may have been directly related to the availability of large oaks for shipbuilding.

Recent dendrochronological study of Dutch and Flemish furniture and sculpture indicates that artists and artisans used oak mainly from the Baltic before 1600, whereas

around 1660 a relative change occurred in the volume of the oak trade, with a shift from the Baltic region to south and central Germany. This trend most likely was a reflection of timber imports for shipbuilding.

Copper sheathing of the sternpost, as seen on *Nassau*, *Batavia*, *Vergulde Draak*, and the Christianshavn B&W 2 shipwreck, continued on VOC ships, as evidenced by the archaeological remains of the VOC ship *Buitenzorg*, which was built at the Amsterdam shipyard in 1753. Archaeological evidence has shown that it was standard VOC practice to sheathe the sternposts of its ships with copper sheets (fastened by copper sheathing tacks) throughout its entire existence. In the case of *Batavia*, the preserved sheathing on the sternpost consisted of one layer of copper sheets, whereas *Vergulde Draak*'s sternpost was covered with multiple layers of copper with a lead lining. No archaeological evidence has been found to date that demonstrates copper sheathing of the stem on any seventeenth- or eighteenth-century VOC ship.

The data from the shipwrecks discussed in this study are not abundant when trying to examine and understand Dutch shipbuilding techniques for large oceangoing ships intended to sail long distances. The modest surviving section of *Batavia*'s hull leaves many questions unanswered. No keel, keelson, stem assembly, floors, or master frames have survived. There is still more to learn from the wreck; for example, many fragments of *Batavia*'s rigging elements have been preserved and still await in-depth study.

VOC shipbuilding of the later seventeenth century is even more of an enigma because archaeological data from Dutch ships of that period are virtually nonexistent. This makes it hard to compare the archaeological data presented in this book to that of VOC ships of a later period to get a better understanding of the changes that occurred in the late seventeenth and early eighteenth centuries and the exact reason for the disappearance of double planking.

In the analysis of *Batavia*'s constructional features with historical sources and archaeological data, it becomes evident that all Dutch *voorcompagnieën* and VOC ships had common traits. Nonetheless, a larger archaeological sample and in-depth analysis of shipbuilding documents, contracts, ship journals, and iconography are needed to get a clearer understanding of Dutch shipbuilding. In addition, parallel studies of English, French, and Iberian ships from this period would provide more defined characteristics of the shipbuilding techniques used to create similar ships for other European seafaring nations.

APPENDIX A

VOC SHIP CONSTRUCTION CHARTERS

Translating excerpts from sixteenth- and seventeenth-century manuscripts on contemporaneous shipbuilding, written in Old Dutch, is a complicated task. The following translations of VOC shipbuilding charters must, therefore, be seen as a conjectural attempt, which undoubtedly will leave many questions unanswered.

Currently, these particular Dutch texts are difficult to understand, do not provide clear answers to current research questions, and leave many unsolved problems. Interpreting Old Dutch terminology and style has proven to be challenging. Terms used in the charters can have more than one meaning, their meaning may have changed throughout time, and/or sometimes their denotation depends solely on the interpretation of contemporary scholars. Consequently, the English translation is even more vague and obscure. The charters translated here are literal translations, which merely reflect the interpretation of the author, and may be of use only to those interested in these important and little-known works and those who do not possess sufficient mastery of the Dutch language.

SHIP CONSTRUCTION CHARTERS, 1603

[From NA, Verenigde Oostindische Compagnie, item no. 99 RJ (Kopie-resoluties van de Heren XVII, 1602–7), folios 63–67.]¹

In the original text a slash (/) indicates a pause in the text; these have been replaced occasionally with paragraph markers to space the text out, or, in the translation, they may be deleted for clarity.

Folio 63

Charter resolved by the Gentlemen XVII on 27 February 1603, for the construction of ships of 600 tons, all measurements in Amsterdam feet and thumbs on the inside of the ship's hull and endposts.

Eerstelijk te besteeden een schip van 130 voeten / langh binnen de stevens	Primarily to apply for a ship of 130 feet / length within the endposts
Wijt binnen de huys 35 voeten	Width within the hull 35 feet
Den overloop ² geleyt op 13 voeten ³ / te meten op 16 voeten hols	The lower deck placed at 13 feet / measured on 16 feet deep
De koebrugghen op 5 voeten	The upper deck at 5 feet
Dat deurgaende boevenet ⁴ op 6½ voeten / achter de mast soo hoogh datter kooyen	The continuing quarterdeck at 6½ feet, aft of the mast so high that the cabins
moghen staen met een open regeling ⁵ ofte / rochgangh ⁶	may be standing with open railing or / caprail
Voor ende agter verheven plegten tot / besteeders will te weten 2½ voeten / agter en voor 3½ voeten daerop de / fortuyninge na eysch vant schip	Raised fore- and afterdecks, ⁷ according to the investor's wish, 2½ feet aft and 3½ feet fore, above which to place the topside planking depending on the ship's requirements

Een goet gallioen met knies ende / regelingen wel
besorcht
Een vierkante gallerye puntigh / gemaect niet langh
op de zyde
De kiel sal breed sijn opt kruys 2 / voeten diep 20
duymen
De voorsteven 33 voeten hooghe ofte / datter de
boeghspruit aengevestigt / wert hebbende omtrent
2 voeten / vallens boght na besteders will
De agtersteven 27 voeten hooghe / ofte 28
hebbende 7 voeten vallens/ behalve d'streeck
die binnenkant / 20 duymen dick buyten toe
gehouden
Dat heck [balk] langh ofte wijt 16 voeten

Folio 64

De spiegel geseth op 13 voeten hooch / wel besorcht
met wulpen / vierkant elf duymen ende een
voet / van een aen elcken ent een goet / knie
insonderheyt aent heck [balck]
Twee knies over de wulpen ende / Langes scheeps
Een goet knie opden kiel aenden / steven / aen
wedersyden van den knoop¹² van de / voorsteven
mede wel besorcht
Het vlack wijt 24 voeten op / 1½ voet rysens
Lenghen 't vlak 50¹³ voeten lanck / te meten wijt in 't
soch¹⁴ op / datter grof houdt om / laegh magh
De twee eerste gangen drie / kimmien ganghen ende
drie kimmien / wegers van swaere Oostersche /
plancken¹⁵
De kimmganghen een / voet breed ende een planck
dick / over d'ander in te komen De middelste /
kimmeweger ½ voet dick om / ront aff te vlacken
ende wel / inde kimmien aen te voegen
Alle die gangen aen de streeck / binnengedreven
De buyckstucken op de kiel dick / 10 duymen ende
inde kimmien oock / op de huyt wel aengevoeght /
breed aght duymen
De sitters elf duymen verschervende¹⁶ / viercant
houdt voorby den anderen / vyff voeten
De huyten wegers van Oostersche / plancken 4 uyt
een voet behouwens / hout alle wel gaeff

A good beakhead well provided with knees and
railings
A square raking gallery, not made long on its side
The keel has to have a width of 2 feet and 20 thumbs
deep on its cross⁸
The stem 33 feet high, so that the bowsprit will be
attached, having about a 2-foot drop [per foot]
curvature, according to the investor's wish⁹
The sternpost 27 feet in height or 28 having a 7-foot
drop [per foot] except for the *streeck*,¹⁰ whose
inner face 20 thumbs thick, tapering toward the
outside
That wing transom long or wide 16 feet

The [transom] stern placed at a height of 13 feet, well
provided with transom beams, square 11 thumbs
and a foot, on each end a good knee, especially
against the wing transom
Two knees over the transom beams and alongships¹¹
A good knee on the keel against the endposts. On
either side of the boxing of the stem also well
provided
The bottom of the hull 24 feet wide rising 1½ feet
Lenghen [hitch?] [at] the bottom 50 feet long,
measuring wide in the hog so heavy wood may go
down
The first two strakes, three bilge strakes, and three
bilge-ceiling strakes of heavy eastern planks
The bilge strakes 1 foot wide and one plank thick over
one another coming into the center bilge ceiling
strake, ½ foot thick, to smooth down roundly and
fit flush into the bilges
All those strakes driven onto the *streeck*
The floor timbers on the keel 10 thumbs in thickness
and in the bilges inserted well, flush against the
hull 8 thumbs in width
The first futtocks 11 thumbs staggered, square timber
beyond the others [floor timbers] 5 feet
The hull and ceiling of eastern planks four out of 1
foot, subject to all wood being soundly flawless

Folio 65

De balckwegers van overloop en koebrugge / ½ voet dick, 2 voeten breed opt smalste endt / de boven kantt vande eerste weger daeraen / even dick beneden op 4 uyt een voet draems wijs

De oplangen tot de scheergangen 8 duymen / dick breed 8 duymen en van de scheergangh / tot de koebrugge 7 duymen ende tot dat hoogste / boort 6 duymen breed nade eysch van 't schip

't Schip boven aen elcke syde 3½ voet ingehaelt / tot besteders believen

De balcken vier voeten van den anderen in 't ruym / 15 duymen viercant opt smalste een voet / boths

De koebrugge 14¹⁸ duymen viercant, 8 duymen / boths

Alle balcken wel met knies versorgt met / vier voeten misslaghs aen de balcken ende de / kimmen voort vant een waterboort / tot 't ander met een borst van twee / duymen onder de balcken / Nogh een klos onder de balcken als een carbeel

Elk balk een spant stuyvens en katte / spoor loopende van beneden tot dat / waterboort vant boevenet ende aen elcke / balck 3 hoogh met een borst onder / 't waterboort dat wat stuyvers / agter de dael¹⁹ sijn sullen oplopen tot / dat hoogste boort alle viercant tien duymen

Een kolsum breed 2 voeten diep een voet

Folio 66

De lijfhouten van den overloop ende koebrugge / dick 7 ende 6½ duymen breed 2 voeten op / 't smalste ent om die stuyvers²⁰ gestreken met keepen / van drie duymen ende in de balcken / gesoncken daaragter gevolt met / klossen aen boort 4 duymen hoogh

Een geschulpte planck op sijn kant / voor de stuyvers ende klossen op den overloop gevoegt / daer 't langs wateren sal door een pijp

Tusschen elcke balck drie / ribben 4 duymen viercant ende / die inde scheerstock ende lijfhouten / gelaten met een viercant / borst een duym diep

The shelf clamps of the lower and upper deck ½ foot thick, 2 feet wide on their narrowest, the topside of the first ceiling [strake] above them equal in thickness [to the ones] below to four out of 1 foot *draems wijs*¹⁷

The futtocks up to the *scheergangen* 8 thumbs thick, 8 thumbs wide, and from the *scheergang* to the upper deck 7 thumbs, and up to the highest side of the hull 6 thumbs wide depending on the requirements of the ship

The ship above on each side 3½ feet tumblehome according to the investor's wishes

The [deck] beams 4 feet from one another in the hold, 15 thumbs square on the narrowest [end] camber 1 foot

The upper deck [beams] 14 thumbs square, 8 thumbs tapered

All [deck] beams well provided with knees having a 4-foot overlap with the beams and bilges, forth from one waterway to another with a shoulder of 2 thumbs below the beams, as well as chock below the beams as a bracket [?]

[For] each beam a rib, support [rider futtock], and a rider frame running from below, to the waterway of the quarterdeck, and to each beam 3 high, with a shoulder below the waterway so that the supports aft of the dale run up to the highest side of the hull, all square 10 thumbs

A keelson 2 feet wide, 1 foot deep

The waterways of the lower deck and upper deck 7 thick and 6½ thumbs wide

2 feet on the smallest end scarfed to the supports [rider futtock] with notches of 3 thumbs and set in the beams aft of which filled with spacers [or chocks] against the side of the hull 4 thumbs high

A notched plank on its side for[e of] the supports [rider futtock] and the spacers [or chocks] fayed on the lower deck, along which the water is drained through a pipe

Between each [deck] beam three ledges 4 thumbs square and inserted in the binding strakes and the waterways with a square shoulder, 1 thumb deep

ende een / lip daerbuyten soo in den overloop als koebrugge	and a <i>lip</i> on the outside, as well in the lower and upper deck
Den overloop en koebrugge digt / gestreecken met droge eecken / Oostersche plancken alsoock / de plegten	The lower and upper deck covered with dry oak eastern planks also the [fore and after] decks
Van den overloop tot dat boevenet / digt gestreecken met wagers op den anderen	From the lower up to the quarterdeck sealed with ceiling planks on one another
Twintigh of 24 poorten tot besteders will	Twenty or 24 [gun] ports according to the investor's wish
Voor en agter een slemphout ²¹ van / beneden tot de cluyssen ende agter tot dat heck	Fore and aft a deadwood from below up to the hawse holes and the aft up to the counter
Voor een goet fockespoor met / agt banden ²² 4 beneden 2 opden / overloop en 2 op de koebrugge / wel langh ende vast	Fore a good maststep with eight breast hooks [or riders] four below, two at the lower deck, and two at the upper deck long enough and fixed
Op de koebrugge verheeven schaerstocken / om de luycken ende daer beneven / drie paar knies van boort ende waterboort / tot verheven scheerstocken vant / boevenet	On the upper deck raised binding strakes at the hatches and, in addition, three pairs of knees [running] from the hull and the waterway up to the raised binding strakes of the quarterdeck
Folio 67	
Drie spant berckhouten d'onderste / twee veerthien ²³ duymen breedt dick 2 plancken / van de huyt dat derde een voet breet dick / 4½ duymen	Three frame wales, the lowest two 14 thumbs wide, thick two planks of the hull, the third 1 foot wide, 4½ thumbs thick
Een raehout en regelingh inde huyt	A planksheer and railing in the hull
Dat boevenet met de pleghten mede / eecken ²⁴ waterboorden ende met goede Pruysche / deelen ²⁵ digt gestreken tot de luycken de luycken / met tralien	That quarterdeck and the decks [smaller decks and platforms], also oak the waterways, and covered with good Prussian planks up to the hatches, the hatches with grating
Een voet hoger geschandect ²⁶ met een / voet planks open regelinghs ende een / styve bosbanck van drie voeten ofte wat / meer voorscheen ²⁷ te hebben ende verheven / scheerstocken	A foot higher spirketted with 1-foot planks, open railings, and a stiff pin rail of 3 feet or more to have bulwarked, and raised binding strakes
Een spilbetingh cruyshouten knegts / eecken vischien ²⁸ om masten en spil bosbanck ²⁹ ende / schiltbancken ³⁰ clampen ende voort al wat / byll en boort eischt oock hier niet / gespecificeert staet	A capstan, kevels [also riding bitts], knightheades, oak partners around the masts and capstain, pin rail and windlass bitts, cleats, and everything else that <i>beam and board</i> ³¹ require, even if not specified here.
Twee kooyuyten / de bovenste soo laegh als 't vallen mach / 't schip verdreven herdeuttelt ³² versogt	Two cabins, the upper one as low as it may fall, the ship driven [caulked], dottled <i>versogt</i> [<i>versorgt?</i> <i>verzocht?</i> <i>versagt?</i> provided?]
Den overloop koebrugge ende boevenet wel / gedreven geteert ende gesmeert de masten gespoort	The lower deck, upper deck, and quarterdeck, well caulked, tarred, and greased, the masts stepped
Daerna met des besteders loot ende haer / bekleet daerop met Oostersche plancken / verdubbelt tot d'onderkant vant / boevenets barckhout wederomme / gedreven ende geteert binnen ende buyten	After which sheathed with lead provided by the commissioner and hair covered with eastern planks [and] doubled up to the underside of the quarterdeck wale, again caulked and tarred inside and outside

[From: NA, Verenigde Oostindische Compagnie, item no. 99 RJ (Kopie-resoluties van de Heren XVII, 1602–7), folio 68.]

Folio 68

Certer vande Jachten groot elck omtrent 80 lasten³³
 Eerstelick langh binnen steven 96 voeten
 Wy 25 voeten
 Holl de overloop 10 voeten
 De koebrughe 4 voeten
 Achter een vast boevenet 6 voeten
 De achterplecht verheven 2½ voeten
 De voorplecht verheven 2 voeten
 Int heck langh 11 voeten
 De Spiegel geset op 10 voeten
 De luycken soo wyt ende lanck als se vallen moghen
 om de sloep er beneden te strycken ende met
 tralies onder de dichte luycken om die bij goet
 weer altyt open te laeten staen
 De bosschieters kamer soo hooch als die vallen mach
 om de slach vant cruyt te verminderen
 Achter t boevent wulft een galderytgen

Charter of yachts each with a size of about 160 tons
 First, length between the endposts 96 feet
 Width 25 feet
 Height of the lower deck 10 feet
 The upper deck 4 feet
 Aft a fixed quarterdeck 6 feet
 The afterdeck raised 2½ feet
 The foredeck raised 2 feet
 The wing transom length 11 feet
 The [transom] stern placed at 10 feet
 The hatches wide and long enough to lower a sloop
 through them and with grating underneath the
 sealed hatch covers in order to leave them open at
 all times in good weather
 The gunner's chamber high enough as it may fall to
 diminish the impact of the gunpowder
 Aft of the quarterdeck vaults a gallery

SHIP CONSTRUCTION CHARTERS, 1614

[From NA, Verenigde Oostindische Compagnie, item no. 100 (Kopie-resoluties van de Heren XVII, 1608–23), folio 271, point 8, 9–20 September 1614.]

Is verstaen dat voortaan de cameran der welcker
 beurte sal wesen eenige nieuwe schepen te
 timmeren de selve sullen doen maecken op een
 vande naervolgende Chartres tot keure vande
 geene die timmeren sal, maer niet grooter nocte
 buijten deselve Chartres.
 Te weten van eenhondert ende vijftich voeten lanck
 drijdertich voeten wijt ende derthien voeten hol
 oft diep met een Coebrugge van vijff voet ende
 een boevenedt daerboven van ses ende drij quart.
 D'ander Charter van hondert (138) achtendertich
 voeten lanck, sesendertich voeten wijt, veerthien
 voeten hol, met een Coebrugge van vijff ende een
 halff voet, ende daer en boven een boevenedt van
 ses ende drijquaert voeten alles in Amsterdamsche
 maete, ofte daertegens gereduceert maeckende
 alsoo elck een schip van drijhondert lasten.
 Den minder soorte ofte Charter sal wesen van
 hondert ende dertich voeten lanck, sessentwintich
 voeten wijt ende twaelf hol met een boevenet van
 ses ende een halff voet. Ofte hondert en

Is understood that henceforth the chambers, which
 are up for the construction of several new ships,
 shall construct following their own preferences,
 but not larger or outside this charter.

Namely of 150 feet in length, 33 feet in beam, and 13
 feet in hold or depth, with an upper deck of 5 feet,
 and a quarterdeck of 6¾.

Another charter of 138 feet in length, 36 feet in beam,
 and 14 feet in depth, with an upper deck of 5½
 feet, and a quarterdeck of 6¾ feet, all done with or
 converted to Amsterdam feet, making each a ship
 of 600 tons accordingly.

The lesser type of charter shall be 138 feet in
 length, 26 feet in beam, and 12 in depth, with
 a quarterdeck of 6½ feet to, hereby, testing the
 approximation to make each ship 300 tons.

veertich voeten lanck, vier ende twintich voeten
wijt, twaelf hol ende een boevenet van ses ende
een halff voet tot een proeve maeckende naer
gissinghe elcx een schip van hondert vijftich last.

SHIP CONSTRUCTION CHARTERS, 1616

[From NA, Verenigde Oostindische Compagnie, item no. 100 (Kopie-resoluties van de Heren XVII, 1608–23), folio 329, no. 20, 24 October 1616.]³⁴

De chartres vande schepen hier naer voorde Comp.
te timmeren sijn gearresteert in voegen ende
manieren als volcht

De groote scheepen van 142 voet over steven
36 voet wijt binnen de huyt
14 voet diep onder³⁵ den overloop
5¼ voet tot de coebrughe
7 voeten tot het boevenet daargaende aen boort
De mindere schepen ofte jachten sullen wesen van
130 voet lanck over stevens
32 voet binnen de huyt
12 voet hol off diep onder de overloop
5 voeten tot aen de coebrugge
6½ voet tot de boevenet doorgaende aen boort

Alles op Amsterdamsche mate off daertegens
gereduceert ende op dat de voors. chartres niet
en werden geexcedeert is geresolveert dat de twee
naest gelegen camers vande gene die timmeren
sullen twee uijt den haren sullen committeren,
omme 't nieuwe hol getimmert sijnde,
perfectelijck te meten ende meerder als de voors.
chartres bevindende sal 't selve schip blijven tot
laste, coste ende schade vande Bewinthebbers in
haer particulier die de voors. chartres geexcedeert
ende eenige schepen in lengde, wijde ofte diepte
grootter dan als voren sullen getimmert hebben
alles in conformite vande resolutie dies aengaende
ter laester vergaderinge genomen.

SHIP CONSTRUCTION CHARTERS, 1653

[From: NA, Verenigde Oostindische Compagnie, item no. 103 (Kopie-resoluties van de Heren XVII, 1608–1796), folios 228–233, 24 May 1653.]³⁶

(Rapport vande Gecommitteerdens wegen de
charters)

Gehoort het rapport vand'Hrn. op eergisteren
gecommitteert omme mette scheepstimmerlieden
vande respective Cameren te besoignieren over

The charters of the ships after which to build for the
Company according to the following requirements
and methods

The large ships of 142 feet across the endposts
36 feet wide on the inside of the hull planking
14 feet deep below the lower deck
5¼ feet up to the upper deck
7 feet to the quarterdeck continuing onto the hull
The lesser ships or yachts should be 130 feet between
the endposts
32 feet width on the inside of the hull
12 feet high or deep below the lower deck
5 feet up to the upper deck
6½ feet up to the quarterdeck continuing onto the
hull

All done with or converted to Amsterdam feet and
so the previous charters will not be exceeded, is
resolved that the two adjacent chambers will take
care of constructing two of those from theirs,
to be built with the new height, to be measured
perfectly, and, more so than with the previous
charters, it shall be the same ship in tonnage,
cost, and compensation of their respective
administrators, who exceeded the previous
charters and have built several ships in length,
width, or depth greater than before, all conform
to the decision considering these made in the last
meeting.

(Report of the delegates regarding the charters)

Taking into account the report of the Gentlemen
delegated the day before yesterday to commit,
with the carpenters of the respective chambers,

de Carters daer op de schepen vande Compagnie soo groote als kleijne nae desen sullen werden getimmert. is nae deliberatie goet gevonden ende verstaen der selver gebesoigneert te approberen ende dienvolgende 't selve hier onder te doen insereren met dien verstande dat de respective Cameren haer nae desen int timmeren van haer schepen nae d'onder gestelte Charters preciselijck sullen moeten reguleren.

Charter van een Retourschip

Dat een retourschip sal wesen langh over steven 160 voet,

wijt 38 voeth,

hol 13 voet,

sonder 'tselve te mogen excederen.

De koebrugge 5 voet,

't boevenet hoogh $7\frac{1}{4}$ voet

dat het schip sal incomen aen ijder vanden schut overloop aff tot op de hoochte van het boeveneth toe $2\frac{1}{2}$ a 3 voeth.

(Dickte en swaerte vant hout)

De kiel sal wesen langh 130 voeth, voor dick 2 voeth;

de voorsteven hoogh 30 voet, dick 17 a 18 duijm;

de achtersteven 27 a 28 voeth, dick 18 duijm;

de heckbalcken langh 24 a 25 voet;

de buijck stucken 4 voet, dick 12 a 13 duijm;

de sitters int hart vande kimmingh 10 a 11 duijm,

op boeijsel dick 9 duijm, op de scheergangh $7\frac{1}{2}$ duijm;

kolsingh dick 10 a 11 duijm, breed $2\frac{3}{4}$ voet;

twee wegers neffens kolsingh ijder dick $5\frac{1}{2}$ duijm;

2 kimwegers off 3;

de bantwegers³⁷ en ganghboorden dick $5\frac{1}{2}$ duijm;

de overlopers balcken 14 a 15 duijm;

de deckbalcken dick 11 duijm;

de driespant barchouten³⁸ 7 duijm dick, breed 14 duijm;

de onderste vollingh dick 5 duijm;

't barchout boven de poorten breed 13 duijm, dick $6\frac{1}{2}$ duijm;

het ander barchout breed 12 duijm, dick 6 duijm;

't reehout breed 10, dick 5 duijm;

d'huijt vant schip tot aent barckhout toe dick 4 duijm;

to the carters after which to build the large and small ships of the Company. After consultation is approved and recognized to approve this commitment and consequently insert it below with the understanding that the respective chambers will have to regulate following these [charters] precisely as specified below and construct their ships accordingly.

Charter of a Return-Voyage Ship

That a return ship will be long across the endposts 160 feet,

38 feet wide,

13 feet high,

Without allowing this to be exceeded.

The upper deck 5 feet,

The quarterdeck $7\frac{1}{4}$ feet high

that the ship will have a tumblehome on either side from the lower gun deck onward up to the height of the quarterdeck $2\frac{1}{2}$ to 3 feet.

(Thickness and dimensions of timber)

The keel shall be 130 feet long, for thickness 2 feet;

the stem 30 feet high, 17 to 18 thumbs thick;

the sternpost 27 to 28 feet, 18 thumbs thick;

the wing transoms 24 to 25 feet long;

the floor timbers 4 feet, 12 to 13 thumbs thick;

the first futtocks in the heart of the bilges 10 to 11 thumbs,

on the board 9 thumbs thick, on the *scheergangh* $7\frac{1}{2}$ thumbs;

keelson 10 to 11 thumbs thick, $2\frac{3}{4}$ feet wide;

two ceiling strakes next to keelson each $5\frac{1}{2}$ thumbs thick;

two bilge strakes or three;

the shelf clamps and gangways $5\frac{1}{2}$ thumbs;

the lower deck's beams 14 to 15 thumbs;

the [upper] deck beams 11 thumbs thick;

the three main wales 7 thumbs thick, 14 thumbs wide;

the lowest filling strake[s]³⁹ 5 thumbs thick;

the wale above the [gun] ports 13 thumbs wide, $6\frac{1}{2}$ thumbs thick;

the other wale 12 thumbs wide, 6 thumbs thick;

the planksheer 10 wide, 5 thumbs thick;

the hull of the ship up to the wale 4 thumbs thick;

de plancken inde breegangh⁴⁰ 3½ duijm dick, boven dick 3 a 2½ duijm;

de plancken vande schut overloop dick 3 duijm;
de koebrugge van goede deelen van 2 a 2½ duijm;

de deelen vant boevenet dick 2 duijm;

om de andre balck een steunder langh tot de knie toe vant boevenet aff de steunders in elcken gangh een off twee bouts nae sij breet zijn inde nebbe⁴¹ vande onderste knie 5 a 6 bouten;

de boevenets knies inde nebbe 4 bouts, het grote gat dick 1 duijm daer het ijser nae geront wort, het tweede gadt ¾ duijm dick.

Charter van een groot Oorlogsjacht

Dat een jacht om ten Oorlogh te gebruijcken sal wesen

langh over steven 134 voeten,
wijt 33 voeten,
hol 13½ voet,
het verdeck hoogh 7½ voet,
de bovenkant vant reehout 4 voet hol verbonden,
d'incomen van het schip op de hoochte van het verdeck 2½ voet aen ijder sij.

(Dicte en swaerte vant hout)

De kiel sal wesen dick 18 duijm vierkant,
de voorsteven dick 15 duijm,
achtersteven van gelijcken,
de voorsteven hoogh 24 voet,
de achtersteven 23 a 23½ voet,
de heckbalck langh 21 a 22 voet,
de buijckstucken 11 duijm;
de sitters int hart vande kimmen 9½ duijm,
op boeijssel dick 7½ a 8 duijm,
op de scheergangh dick 6½ duijm,
boven op de dolboom⁴² 4½ duijm;
kolssingh dick 9 duijm,
breet 2½ voeth;
wegers 2 neffens kolssingh ijder dick 5 duijm;
de twee kimwegers ijder 5 duijm dick;

the planks of the *breegangh* [strakes of hull planking between gun ports] 3½ thumbs thick, above three to 2½ thumbs;

the planking of the lower gun deck 3 thumbs thick;
the upper deck of good boards [pine planks] of 2 to 2½ thumbs;

the boards [pine planks] of the quarterdeck 2 thumbs thick;

at every other beam a rider long up to the knee, from the quarterdeck down, the riders in each strake one or two bolts depending on its width, in the head [or beam arm] from the lowest [standing] knee five to six bolts;

the quarterdeck [standing] knees in the head [or beam arm] four bolts, the large hole 1 thumb thick after which the iron is rounded, the second hole ¾ thumb thick.

Charter of a Large War-Yacht

That a yacht to be used during war shall be

over its endposts 134 feet long,
33 feet wide,
13½ feet high,
the upper deck 7½ feet high,
the topside of the planksheer attached 4 feet high,
the tumblehome of the ship at the height of upper deck 2½ feet on either side.

(Thickness and dimensions of timber)

The keel shall be 18 thumbs square thick,
the stem 15 thumbs thick,
the sternpost equally so,
the stem 24 feet high,
the sternpost 23 to 23½ feet,
the wing transom 21 to 22 feet long,
the floor timbers 11 thumbs;
the first futtocks in the heart of the bilges 9½ thumbs,
on the board 7½ to 8 thumbs thick,
on the *scheergangh* 6½ thumbs thick,
on top of the gunwale 4½ thumbs;
keelson 9 thumbs thick,
2½ feet wide;
ceiling strakes two on each side of the keelson each 5 thumbs thick;
the two bilge ceiling strakes each 5 thumbs thick;

bantwegers en ganghboorden dick 5 duijm;
 overloopsbalcken 13 a 14 duijm dick;
 deckbalcken 10 a 11 duijm;
 2 span barckhouten 6½ duijm,
 breet 13 a 14 duijm;
 't barckhout boven de poorten dick 6 duijm, breet 12
 duijm;
 het opperste barckhout dick 5½,
 breet 11 duijm;
 't reehout dick 4½ duijm,
 breet 9 duijm;
 d'huijt vant schip dick 4 duijm tot onder de poorten
 toe;
 de plancken inde breegangh dick 3 duijm daer boven
 dick 2½ duijm;

 de plancken van de schutoverloop dick 2½ duijm;
 de koebrugge van goede deelen van 2 duijm;

 7 a 8 spansteunders, de steunders in elcken gangh
 een bout;
 inde knies van gelijcken inde nebbe vand'onderste
 knies 4 a 5 bouts;

 de boevenets knies, inde head 3 a 4 bouts;

 't groote gadt dick 1 duijm daer het ijser nae geront
 wort;
 het tweede gadt ¾ duijm dick.
 de kiel sal wesen langh 111 voeten
 achter vallens 3½ voeten
 voor vallens 19½ voeten

Charter van een Coopvaardijjacht om mede ten Oorlogh te kunnen gebruijcken.

Dat een jacht om op Coopvaerdij te gebruijcken ofte
 ten Oorlogh soo 't gelegen is
 sal wesen langh over steven 126 voet,
 wijt 28 voet,
 hol 12 voet
 het verdeck hoogh 6½ voet
 d'incomen vant schip op d'hoochte vant verdeck 2¼
 voeth aen ijder zij.
 (Dicte en swaerte van't hout)
 De kiel sal wesen dick 17 duijm vierkandt,

the shelf clamps and gangways 5 thumbs thick;
 lower deck beams 13 to 14 thumbs thick;
 deck beams 10 to 11 thumbs;
 2 timber wales 6½ thumbs,
 13 to 14 thumbs wide;
 the wale above the [gun] ports 6 thumbs thick, 12
 thumbs wide;
 the upper wale 5½ thick,
 11 thumbs wide;
 the planksheer 4½ thumbs thick,
 9 thumbs wide;
 the hull of the ship 4 thumbs thick up to the [gun]
 ports;
 the planks in the *breegangh* [strakes of hull planking
 between gun ports] 3 thumbs thick above which
 2½ thumbs thick;
 the planking of the lower gun deck 2½ thumbs thick;
 the upper deck of good boards [pine planks] of 2
 thumbs;
 seven to eight rider frames, the riders in each strake
 a bolt;
 similar in the [hanging] knees, in the head [or beam
 arm] of the lowest [standing] knees four to five
 bolts;
 the quarterdeck's knees, in the head [or beam arm]
 three to four bolts;
 the large hole 1 thumb thick after which the iron is
 rounded
 the second hole ¾ thumb thick.
 the keel shall be 111 feet long
 aft drop [curvature, per foot] 3½ feet
 fore drop [curvature, per foot] 19½ feet

Charter of a Merchant Yacht Also to Be Used in War

That a yacht to be used for the mercantile or for war
 as is applicable
 shall be across its endposts 126 feet long,
 28 feet wide,
 12 feet high
 The upper deck 6½ feet high
 the ship's tumblehome at the height of the upper
 deck 2¼ feet on either side
 (Thickness and dimensions of timber)
 The keel shall be 17 thumbs square thick,

de voorsteven dick 14 duim,
 achtersteven van gelijken,
 de voorsteven hooch $21\frac{1}{2}$ voet
 de achtersteven hooch 21 voet,
 de heckbalcken 19 a 20 voet lanck;
 de buijckstucken 10 duim;
 de sitters int hart vande kimmen dick $8\frac{1}{2}$ duim,
 op boeijsel 7 duim,
 op de scheergangh 6 duim,
 boven op de dolboom dick 4 duim;
 kolssingh dick 8 duim, breed $2\frac{1}{4}$ voet;
 2 kimwegers dick $4\frac{1}{2}$ duim;
 bantweger $4\frac{1}{2}$ duim;
 de balcken vanden overloop 12 a 13 duim;
 ganghboorden dick 5 duim met een waterloop⁴³ aen
 boort uijtgehouden;
 deckbalcken 7 a 8 duim;
 twee spanbarckhouten dick 6 duim,
 breed 12 a 13 duim;
 't barckhout boven de poorten dick $5\frac{1}{2}$ duim,
 breed 11 duim;
 het opperste barckhout dick 5,
 breed 10 duim;
 't reehout dick 4 duim,
 breed 8 duim;
 d'huijt vant schip $3\frac{1}{2}$ dick tot het onderste barckhout
 toe,
 de plancken inde breegangh dick $2\frac{1}{2}$,
 daerboven 2 duim; de deelen vanden schutoverloop
 dick $2\frac{1}{2}$ duim;
 het boevenet dick 2 duim, in elcke gangh een bout;
 in de nebbe vande onderste knies 4 bouts,
 de bovenste knies inde nebbe 3 bouts,
 de bouten met het gadt geboort van $\frac{3}{4}$ doorgaens.

Charter van een kleijn jacht

Dat een kleijn jacht sal wesen langh over steven 116
 voet,
 wijt 26 voet,
 hol 10 voeth,
 het verdeck hooch $5\frac{1}{2}$ voet d'incomen van dit schip
 op de hoochte van het verdeck $2\frac{1}{4}$ voet aen ijder
 sij.

the stem 14 thumbs thick,
 the sternpost equally so,
 the stem $21\frac{1}{2}$ feet high,
 the sternpost 21 feet high,
 the wing transom 19 to 20 feet long;
 the floors 10 thumbs;
 the first futtocks in the heart of the bilges $8\frac{1}{2}$ thumbs,
 on the board 7 thumbs,
 on the *scheergang* 6 thumbs,
 on top the gunwale 4 thumbs thick;
 keelson 8 thumbs thick, $2\frac{1}{4}$ feet wide;
 2 bilge ceiling strakes $4\frac{1}{2}$ thumbs thick;
 shelf clamp $4\frac{1}{2}$ thumbs;
 the beams of the lower deck 12 to 13 thumbs;
 gangways 5 thumbs thick with a waterway cut out
 aboard;
 deckbeams 7 to 8 thumbs;
 two main wales 6 thumbs thick,
 12 to 13 thumbs wide;
 the wale above the [gun] ports $5\frac{1}{2}$ thumbs thick,
 11 thumbs wide;
 the upper wale 5 thick,
 10 thumbs wide;
 the planksheer 4 thumbs thick,
 8 thumbs wide;
 the hull of the ship $3\frac{1}{2}$ thick up to the lowest wale,
 the planks in the *breegangh* [strakes of hull planking
 between gun ports] $2\frac{1}{2}$ thick,
 above which 2 thumbs; the boards of the lower gun
 deck $2\frac{1}{2}$ thumbs thick;
 the quarterdeck 2 thumbs thick, in each strake a bolt;
 in the head [or beam arm] of the lowest [standing]
 knees four bolts,
 the upper [hanging] knees in the head [or beam arm]
 three bolts,
 the bolts drilled with a hole of $\frac{3}{4}$ generally.

Charter of a Small Yacht

That a small yacht shall be across its endposts 116 feet
 long,
 26 feet wide,
 10 feet high,
 the upper deck $5\frac{1}{2}$ feet high to this ship's
 tumblehome at the height of the upper deck $2\frac{1}{4}$
 feet on either side.

(Dicte en swaerte vant hout)

De kiel sal wesen dick 16 duim;
 de voorsteven dick 12 a 13 duim,
 achtersteven van gelijcken;
 de voorsteven hooch 20½ voeth,
 d'achtersteven 19 a 20 voeth;
 de heckbalck 18 a 19 voeth;
 de buijckstucken dick 8½ duim;
 de sitters int hart van de kimmen 7½ duim,
 op boeijsel 6½ duim,
 op de scheergangh 5½ duim,
 boven op de dolboom dick 4 duim;
 kolssingh 7½ duim dick,
 breed 2 voeth;
 twee kimwegers dick 4 duim;
 balckweger dick 4½ duim;
 de balcken vande overloop dick 11 duim;
 ganghboort dick 4½ duim,
 met den waterloop aen boort uijtgehouden;
 deckbalcken 6 a 7 duim;
 twee spanbarchouten dick 5½ duim,
 breed 11 a 12 duim;
 't barchout boven de poorten dick 4½ duim,
 breed 10 duim;
 het opperste barckhout dick 4 duim,
 breed 9 duim;
 't reehout dick 3½ duim,
 breed 7 duim;
 d'huijt vant schip 3½ duim geboeijt d'huijt deck van
 3 duijms plancken,
 voors de plancken altemael twee duim;
 het boevenet dick 1¾ duim;
 in elcke gangh een bout inde nebbe vande onderste
 knies 4 bouts;
 de bovenste knies inde nebbe drie bouts a twee,

 de bouten met het gadt geboort van ¾ doorgaens.
 Alles te meten met Amsterdamse voeten ende op de
 peenen begrepen inde resolutie vanden 2 octob
 1651.

(Thickness and dimensions of timber)

The keel shall be 16 thumbs thick;
 the stem 12 to 13 thumbs thick,
 the sternpost equally so;
 the stem 20½ feet high,
 the sternpost 19 to 20 feet;
 the wing transom 18 to 19 feet;
 the floors 8½ thumbs thick;
 the first futtocks in the heart of the bilges 7½ thumbs,
 on the board 6½ thumbs,
 on the *scheergang* 5½ thumbs,
 on top the gunwale 4 thumbs thick;
 keelson 7½ thumbs thick,
 2 feet wide;
 two bilge ceiling strakes 4 thumbs thick;
 shelf clamp 4½ thumbs thick;
 the beams of the lower deck 11 thumbs thick;
 gangway 4½ thumbs thick,
 with a waterway cut out aboard;
 deck beams 6 to 7 thumbs;
 two main wales 5½ thumbs thick,
 11 to 12 thumbs wide;
 the wale above the [gun] ports 4½ thumbs thick,
 10 thumbs wide;
 the upper wale 4 thumbs thick,
 9 thumbs wide;
 the planksheer 3½ thumbs thick,
 7 thumbs wide;
 the hull of the ship 3½ thumbs planked, the deck
 planking of 3 thumbs per plank,
 and then all the planks 2 thumbs;
 the quarterdeck 1¾ thumbs thick;
 in each strake one bolt and in the head [or beam
 arm] of the lowest [standing] knees four bolts;
 the upper [hanging] knees in the head [or beam arm]
 three bolts to two,
 The bolts generally with a hole drilled of ¾.
 All to be measured according to Amsterdam feet and
 on the penalties understood in the resolution of 2
 October 1651.

APPENDIX B

CATALOG OF *BATAVIA* HULL REMAINS

All measurements are maximum linear horizontal and vertical dimensions taken from *Batavia*'s timbers, with the exception of knees, for which length is the direct measurements between the two ends, and thickness is the maximum molded dimension at the intersection of the two arms (see fig. 4-74). For frame, sternpost, and transom timbers, the width measurement represents the sided dimension; and the thickness, the molded dimension.

ID	Catalog number	Description	Location	Field number	Maximum preserved length (meters)	Maximum preserved width (meters)	Maximum preserved thickness (meters)
1	BAT 0582	Copper sheathing fragment	Sternpost	—	0.340	0.400	0.003
2	BAT 3149	Copper sheathing fragment	Sternpost	—	0.175	0.146	0.002
3	BAT 3232 A	Copper sheathing fragment	Sternpost	—	0.196	0.070	0.003
4	BAT 3232 B	Copper sheathing fragment	Sternpost	—	0.165	0.060	0.002
5	BAT 3270	Copper tack	Sternpost	—	0.032	0.005	0.005
6	BAT 3438	Copper sheathing fragment	Sternpost	—	0.345	0.095	0.003
7	BAT 3484	Copper tack	Sternpost	—	0.030	0.005	0.005
8	BAT 3649	Copper sheathing fragment	Sternpost	—	0.134	0.070	0.003
9	BAT 3724	Copper tack	Sternpost	—	0.034	0.005	0.005
10	BAT 3754	Copper sheathing fragment	Sternpost	—	0.185	0.102	0.002
11	BAT 3776	Copper tack	Sternpost	—	0.030	0.006	0.006
12	BAT 3792 A	Copper tack	Sternpost	—	0.034	0.005	0.005
13	BAT 3792 B	Copper tack	Sternpost	—	0.031	0.006	0.006
14	BAT 3827	Copper sheathing fragment	Sternpost	—	—	—	—
15	BAT 3829	Copper sheathing fragment	Sternpost	—	0.185	0.115	0.003
16	BAT 3831	Copper tack	Sternpost	—	0.028	0.006	0.006
17	BAT 6001	Frame timber	C2	C2	0.513	0.184	—
18	BAT 6003	Frame timber	C1	C1	1.170	0.195	0.146
19	BAT 6011	Hull planking, inner layer	Strake 10	P3A/D3	2.782	0.366	0.095
20	BAT 6012	Hull planking, inner layer	Strake 12	P5A/D5	3.440	0.324	0.090
21	BAT 6013	Hull planking, inner layer	Strake 11	P4A/D4	3.238	0.383	—
22	BAT 6014	Hull planking, outer layer	Strake 12	P5B/E6	1.092	0.279	0.060
23	BAT 6015	Hull planking, inner layer	Strake 11	P4A/D4	1.085	0.245	0.098
24	BAT 6017	Frame timber	C17	C17	2.340	0.225	0.195
25	BAT 6018	Frame timber	C16	C16	2.070	0.255	0.215
26	BAT 6020	Frame timber	C9	C9	1.490	0.180	0.185
27	BAT 6021	Frame timber	C10	C10	1.032	0.155	0.160
28	BAT 6022	Frame timber (2 fragments)	C3	C3	1.370	0.218	0.182

ID	Catalog number	Description	Location	Field number	Maximum preserved length (meters)	Maximum preserved width (meters)	Maximum preserved thickness (meters)
29	BAT 6023	Frame timber	C15	C15	0.995	0.170	0.215
30	BAT 6024	Frame timber	C7	C7	2.025	0.180	0.210
31	BAT 6025	Frame timber (2 fragments)	C4	C4	1.178	0.183	0.160
32	BAT 6027	Frame timber	C8	C8	1.442	0.226	0.200
33	BAT 6028	Frame timber (2 fragments)	C5	C5	1.732	0.221	0.178
34	BAT 6029	Frame timber	C14	C14	1.900	0.240	0.205
35	BAT 6030	Hull planking, inner layer	Strake 8	P1A/D1	2.429	0.451	0.087
36	BAT 6031	Hull planking, inner layer	Strake 9	P2A/D2	3.099	0.444	0.086
37	BAT 6032	Hull planking, outer layer	Strake 7	PoB/E1	1.997	0.313	—
38	BAT 6033	Hull planking, outer layer	Strake 9	P2B/E3	2.500	0.355	—
39	BAT 6034	Hull planking, outer layer	Strake 8	P1B/E2	2.305	0.365	0.085
40	BAT 6035	Frame timber	C6	C6	1.318	0.155	0.200
41	BAT 6037	Frame timber	C13	C13	0.605	0.163	0.115
42	BAT 6038	Hull planking, outer layer	Strake 8	P1B/E2	0.708	0.181	0.075
43	BAT 6039	Frame timber	C18	C18	0.950	0.175	0.188
44	BAT 6040	Frame timber	C19	C19	2.657	0.248	0.200
45	BAT 6041	Frame timber	C20	C20	1.025	0.205	0.205
46	BAT 6042	Frame timber	C21	C21	1.150	0.225	0.205
47	BAT 6043	Frame timber	C22	C22	1.692	0.185	0.205
48	BAT 6044	Frame timber	C23	C23	1.440	0.225	0.205
49	BAT 6045	Frame timber	C24	C24	1.265	0.144	0.220
50	BAT 6047	Frame timber	C26	C26	1.510	0.260	0.225
51	BAT 6048	Frame timber	C27	C27	0.628	0.135	0.112
52	BAT 6049	Frame timber	C28	C28	1.870	0.210	0.229
53	BAT 6052	Frame timber	C26	C26	1.440	0.269	0.255
54	BAT 6053	Frame timber	C28	C28	—	—	—
55	BAT 6055	Frame timber	C23	C23	2.030	0.220	0.197
56	BAT 6056	Frame timber	C21	C21	2.445	0.215	0.210
57	BAT 6057	Ceiling planking	Strake 4	1	1.235	0.267	—
58	BAT 6058	Ceiling planking	Strake 4	2	0.620	0.163	0.060
59	BAT 6059	Ceiling planking	Strake 4	3	0.694	0.151	0.071
60	BAT 6060	Ceiling planking	Strake 5	4	0.623	0.139	—
61	BAT 6061	Ceiling planking	Strake 6	5	1.009	0.183	0.066
62	BAT 6062	Ceiling planking	Strake 7	6	1.431	0.313	—
63	BAT 6063	Ceiling planking	Strake 7	7	0.901	0.192	0.080
64	BAT 6064	Ceiling planking	Strake 9	13	0.415	0.154	0.190
65	BAT 6065	Frame timber	C20	C20	1.149	0.198	0.188
66	BAT 6068	Hull planking, inner layer	Loose find	—	1.142	0.318	0.090
67	BAT 6069	Frame timber	C27	C27	0.890	0.210	0.215
68	BAT 6071 A	Hull planking, inner layer	Strake 8	P1A/D1	1.251	0.224	—

ID	Catalog number	Description	Location	Field number	Maximum preserved length (meters)	Maximum preserved width (meters)	Maximum preserved thickness (meters)
69	BAT 6071 B	Hull planking, inner layer	Strake 7	P1A/D1	0.539	0.105	—
70	BAT 6072	Hull planking, second wale	Strake 16	P7A/D9	1.487	0.338	0.140
71	BAT 6073	Hull planking	Strake 15	P8A/D8	2.408	0.343	0.104
72	BAT 6074	Hull planking, inner layer	Strake 11	P4A/D4	2.749	0.367	0.084
73	BAT 6075	Hull planking	Strake 15	P8A/D8	1.257	0.356	0.112
74	BAT 6076	Hull planking, inner layer	Strake 10	P3A/D3	2.427	0.384	0.095
75	BAT 6077	Hull planking, inner layer	Strake 9	P2A/D2	2.285	0.276	0.086
76	BAT 6078	Hull planking, first wale	Strake 13	P6A/D6	2.392	0.345	0.180
77	BAT 6079	Hull planking, inner layer	Strake 8	P1A/D1	0.711	0.224	—
78	BAT 6082	Hull planking	Strake 14	P7A/D7	2.371	0.294	0.125
79	BAT 6083	Hull planking, inner layer	Strake 10	P3A/D3	0.911	0.365	0.092
80	BAT 6084	Hull planking	Strake 14	P7A/D7	1.996	0.326	0.080
81	BAT 6085	Hull planking, inner layer	Strake 8	P1A/D1	0.429	0.234	0.087
82	BAT 6086 A	Hull planking, inner layer	Strake 9	P2A/D2	1.235	0.116	0.086
83	BAT 6086 B	Hull planking, inner layer	Strake 8	P1A/D1	1.087	0.191	0.086
84	BAT 6087	Hull planking, inner layer	Strake 9	P2A/D2	1.200	0.121	0.086
85	BAT 6088	Pine sheathing	Unknown, forward section	—	1.361	0.282	0.017
86	BAT 6089	Cargo floor	Strake 8	9	0.333	0.356	0.016
87	BAT 6091	Hull planking	Strake 17	D10	0.459	0.284	0.120
88	BAT 6095	Hull planking, first wale	Strake 13	P6A/D6	1.573	0.356	0.130
89	BAT 6096	Hull planking, first wale	Strake 13	P6A/D6	1.304	0.359	0.170
90	BAT 6097	Hull planking, inner layer	Strake 12	P5A/D5	2.362	0.289	0.090
91	BAT 6098	Hull planking, outer layer	Strake 8	P1B/E2	2.704	0.363	0.085
92	BAT 6099	Hull planking, outer layer	Strake 10	P3B/E4	3.100	0.322	0.080
93	BAT 6100	Hull planking, outer layer	Strake 9	P2B/E3	2.982	0.332	—
94	BAT 6101	Hull planking, outer layer	Strake 8	P1B/E2	0.659	0.143	—
95	BAT 6102	Hull planking, outer layer	Strake 11	P4B/E5	2.687	0.336	0.070
96	BAT 6103	Hull planking, outer layer	Strake 11	P4B/E5	2.371	0.423	0.086
97	BAT 6104	Hull planking, outer layer	Strake 9	P2B/E3	1.268	0.267	0.070
98	BAT 6105	Hull planking, outer layer	Strake 11	P4B/E5	0.662	0.156	0.070
99	BAT 6106	Hull planking, outer layer	Strake 12	P5B/E6	2.387	0.351	0.070
100	BAT 6107	Hull planking, outer layer	Strake 11	P4B/E5	1.168	0.266	—
101	BAT 6109	Hull planking, outer layer	Strake 12	P5B/E6	2.378	0.342	—
102	BAT 6110	Hull planking, outer layer	Strake 10	P3B/E4	2.111	0.337	0.080
103	BAT 6113	Frame timber	C24	C24	1.180	0.130	0.225
104	BAT 6130	Hanging knee, upper deck	At C31	14	1.82	0.276	0.305
105	BAT 6131	Hull planking, outer layer	Strake 10	P3B/E4	1.178	0.343	—
106	BAT 6136	Pine sheathing, inner layer	Strake 15	SK1A	1.382	0.384	—
107	BAT 6137	Pine sheathing, inner layer	Strake 14	SK1B	1.280	0.295	—

ID	Catalog number	Description	Location	Field number	Maximum preserved length (meters)	Maximum preserved width (meters)	Maximum preserved thickness (meters)
108	BAT 6138	Pine sheathing, inner layer	Strakes 12–13	SK1C	0.606	0.197	—
109	BAT 6139	Pine sheathing, inner layer	Strakes 12–13	SK1D	1.449	0.275	—
110	BAT 6140	Pine sheathing, inner layer	Strakes 12–13	SK1E	0.277	0.125	—
111	BAT 6141	Pine sheathing, inner layer	Strake 15	SK2A	1.271	0.373	0.029
112	BAT 6142	Pine sheathing, inner layer	Strake 15	SK2B	0.945	0.177	—
113	BAT 6143	Pine sheathing, inner layer	Strake 14	SK3A	2.228	0.339	—
114	BAT 6144	Pine sheathing, inner layer (2 fragments)	Strake 14	SK3B	0.869	0.160	—
115	BAT 6145	Pine sheathing, inner layer	Strake 14	SK3B	0.551	0.054	—
116	BAT 6146	Pine sheathing, outer layer	Strakes 13–14	SK4	2.550	0.487	—
117	BAT 6147	Pine sheathing, inner layer	Strakes 12–13	SK5A	0.490	0.284	—
118	BAT 6148	Pine sheathing, inner layer	Strakes 12–13	SK5B	0.409	0.130	—
119	BAT 6149	Pine sheathing, inner layer	Strakes 12–13	SK5C	1.434	0.441	0.029
120	BAT 6150	Pine sheathing, inner layer	Strakes 12–13	SK6A	0.912	0.316	—
121	BAT 6151	Pine sheathing, inner layer	Strakes 12–13	SK6B	0.576	0.170	—
122	BAT 6152	Pine sheathing, inner layer	Strakes 12–13	SK6C	1.303	0.471	—
123	BAT 6153	Pine sheathing, inner layer	Strakes 12–13	SK5D	0.786	0.218	—
124	BAT 6160	Hull planking, outer layer	Strake 2	E-7	3.425	0.303	0.070
125	BAT 6161	Hull planking, outer layer	Strake 1	E-8	2.809	0.361	—
126	BAT 6162	Hull planking, outer layer	Strake 2	E-7	1.667	0.264	—
127	BAT 6163	Hull planking, outer layer	Strake 2	E-7	0.621	0.113	—
128	BAT 6167	Frame timber	C29	C29	3.972	0.206	0.228
129	BAT 6168	Hull planking	Strake 17	D10	1.509	0.352	0.123
130	BAT 6169	Frame timber	C27	C27	2.695	0.202	0.190
131	BAT 6170	Frame timber	C30	C30	2.358	0.219	0.212
132	BAT 6171	Wedge	C26	C26	0.420	0.189	0.135
133	BAT 6172	Frame timber	C23	C23	0.750	0.213	0.203
134	BAT 6174	Frame timber	C26	C26	1.340	0.169	0.190
135	BAT 6175	Hull planking	Strake 18	D11	0.745	0.338	0.100
136	BAT 6176	Hull planking, third wale	Strake 19	D12	1.386	0.361	0.193
137	BAT 6177	Frame timber	C30	C30	2.146	0.214	0.190
138	BAT 6178	Gun port lid	Strakes 18–19	D11–D12	0.615	0.585	0.160
139	BAT 6179	Knee or floor from stern	Loose find	W10	1.300	0.300	0.400
140	BAT 6180	Hull planking, outer layer	Strake 4	E-5	1.531	0.326	0.070
141	BAT 6181	Frame timber	C25	C25	3.217	0.220	0.230
142	BAT 6182	Hull planking, inner layer	Strake 3	D-6	2.095	0.397	0.085
143	BAT 6183	Hull planking, outer layer	Strake 3	E-6	2.875	0.408	0.050
144	BAT 6184	Hull planking, inner layer	Strake 4	D-5	1.260	0.254	0.085
145	BAT 6185	Shelf clamp	Strake 8	8	1.189	0.415	0.120
146	BAT 6188	Ceiling planking	Strake 11	11	0.777	0.263	0.080

ID	Catalog number	Description	Location	Field number	Maximum preserved length (meters)	Maximum preserved width (meters)	Maximum preserved thickness (meters)
147	BAT 6192	Hull planking, inner layer	Strake 4	D-5	0.583	0.214	0.089
148	BAT 6194	Hull planking, inner layer	Strake 5	D-4	1.042	0.323	—
149	BAT 6195	Hull planking, inner layer	Strake 5	D-4	0.847	0.316	0.066
150	BAT 6196	Ceiling planking	Strake 10	B9	1.010	0.340	—
151	BAT 6200	Hull planking, inner layer	Strake 3	D-6.2	0.648	0.122	0.082
152	BAT 6202	Hull planking, outer layer	Strake 11	E4	1.449	0.320	0.038
153	BAT 6203	Hull planking, outer layer	Strake 12	E5	1.498	0.305	0.037
154	BAT 6204 A	Hull planking, inner layer	Strake 9	D2, D1	1.557	0.394	—
155	BAT 6204 B	Hull planking, inner layer	Strake 8	Do	1.595	0.233	0.070
156	BAT 6204 C	Hull planking, inner layer	Strake 8	D-1	1.618	0.198	0.070
157	BAT 6206	Hull planking, inner layer	Strake 11	D4	0.939	0.258	0.086
158	BAT 6207	Hull planking, outer layer	Strake 9	E2	0.520	0.105	0.040
159	BAT 6208	Hull planking, outer layer	Strake 10	E3	1.436	0.318	0.040
160	BAT 6209	Hull planking, inner layer	Strake 11	D4	1.293	0.338	0.091
161	BAT 6210	Hull planking, inner layer	Strake 10	D3	1.497	0.381	0.092
162	BAT 6211	Hull planking	Strake 15	D8	1.537	0.359	0.125
163	BAT 6212	Hull planking, inner layer	Strake 12	D5	1.491	0.288	—
164	BAT 6213	Hull planking, inner layer	Strake 7	D-2	1.340	0.420	—
165	BAT 6214	Hull planking, inner layer	Strake 7	D-2	0.414	0.176	—
166	BAT 6215	Hull planking, first wale	Strake 13	D6	1.499	0.355	0.130
167	BAT 6216	Hull planking	Strake 14	D7	1.472	0.294	0.125
168	BAT 6217	Hull planking, second wale	Strake 16	D9	1.467	0.340	0.150
169	BAT 6218	Margin plank or waterway	Lower deck	—	1.701	0.312	0.107
170	BAT 6219	Hull planking, outer layer	Strake 10	E3	0.572	0.153	0.040
171	BAT 6220	Cleat, 3 sections	Transom knee	—	0.856	0.551	0.088
172	BAT 6221	Planking, same as BAT 6222	On BAT 6223 A	—	1.318	0.294	0.036
173	BAT 6222	Planking, same as BAT 6221	On BAT 6223 A	—	—	—	—
174	BAT 6223 A	Transom knee	Transom/side	A7	3.632	0.363	0.620
175	BAT 6223 B	Transom knee, wing	Transom/side	A8	3.400	—	—
176	BAT 6224	Filling wedge	Underneath 6223	A7-2	1.161	0.339	0.108
177	BAT 6225	Transom ceiling planking	Between T3 and T7	—	0.945	0.244	0.073
178	BAT 6226	Plank, diagonally placed, between transom and side ceiling planking	Between A5 and A7	—	1.393	0.249	0.076
179	BAT 6227	Hanging knee, lower deck	At C31	A6	1.517	0.240	0.304
180	BAT 6228	Transom knee	Transom/side	A1	2.646	0.346	0.312
181	BAT 6229	Lodging knee, lower deck	Transom/side	A3	1.492	0.284	0.488
182	BAT 6230	Deck beam, lower deck	Shelf clamp, fore	—	0.605	0.332	0.325
183	BAT 6232	Cargo floor	Below A2	—	1.758	0.270	0.092
184	BAT 6233	Platform planking	On BAT 6223 A	A3-2	0.411	0.103	0.075

ID	Catalog number	Description	Location	Field number	Maximum preserved length (meters)	Maximum preserved width (meters)	Maximum preserved thickness (meters)
185	BAT 6235	Bung from hawse hole	Transom	—	0.248	0.130	0.081
186	BAT 6240	Pine sheathing	Sternpost, starboard	—	0.566	0.349	0.028
187	BAT 6241	Pine sheathing	Sternpost, starboard	—	0.527	0.453	0.028
188	BAT 6242	Pine sheathing	Sternpost, starboard	—	0.458	0.431	0.027
189	BAT 6243	Pine sheathing	Sternpost, starboard	—	0.412	0.443	0.026
190	BAT 6244	Pine sheathing	Sternpost, starboard	—	—	—	—
191	BAT 6245	Pine sheathing	Sternpost, starboard	—	0.193	0.159	0.027
192	BAT 6246	Cover planking	Sternpost, starboard	—	0.403	0.438	0.058
193	BAT 6247	Cover planking	Sternpost, starboard	—	—	—	—
194	BAT 6248	Cover planking	Sternpost, starboard	—	0.404	0.315	0.049
195	BAT 6249	Cover planking	Sternpost, starboard	—	0.429	0.331	0.049
196	BAT 6250	Cover planking	Sternpost, starboard	—	0.477	0.342	0.045
197	BAT 6251	Cover planking	Sternpost, starboard	—	0.643	0.268	0.045
198	BAT 6259	Ceiling planking	Strake 13	B13	2.286	0.328	0.085
199	BAT 6260*	Ceiling planking, subfloor	Strake 12	B12	2.150	0.471	0.035
200	BAT 6260	Ceiling planking	Strake 12	B12	2.150	0.471	0.090
201	BAT 6261	Ceiling planking	Strake 11	B11	2.014	0.252	0.067
202	BAT 6262	Ceiling planking	Strake 12	B12	0.951	0.247	0.085
203	BAT 6263	Ceiling planking	Strake 10	B10	2.911	0.400	0.090
204	BAT 6264	Ceiling planking	Strake 10	B10	2.271	0.400	0.090
205	BAT 6267	Ceiling planking	Strake 4	B5	2.412	0.357	0.066
206	BAT 6268	Ceiling planking	Strake 3	—	0.928	0.165	0.066
207	BAT 6269 A	Cargo floor	Strakes 2–3	—	1.896	0.352	0.026
208	BAT 6269 B	Ceiling planking	Strake 3	—	1.665	0.619	0.063
209	BAT 6270	Ceiling planking	Strake 2	—	1.991	0.281	0.070
210	BAT 6271 A	Cargo floor	Strakes 1–2	—	1.877	0.560	0.026
211	BAT 6271 B	Ceiling planking	Strake 1	—	0.857	0.166	0.060
212	BAT 6272	Ceiling planking	Strake 1	—	1.466	0.328	0.062
213	BAT 6273	Cargo floor	Strake 1	—	1.713	0.524	0.036
214	BAT 6276	Ceiling planking, subfloor	Strake 12	B12	0.158	0.183	0.049
215	BAT 6286	Gun port frame or sill fragment	Transom	T7-A	0.565	0.163	0.227
216	BAT 6288	Crossbeam	Transom	T7-1	0.668	0.144	0.147
217	BAT 6289	Frame timber	C37	C37	0.546	0.195	0.207
218	BAT 6290	Wedge	C40	C40	0.184	0.264	0.090
219	BAT 6291	Cross beam	Transom	T7-2	0.636	0.117	—
220	BAT 6294	Cardinal's hat, half (joins BATs 6347 and 6348)	Transom	TP13/TP14	0.322	0.322	—
221	BAT 6295	Transom knee	Transom/side	A5	3.178	0.353	0.484
222	BAT 6296	Transom knee	Transom/side	A2	3.069	0.357	0.555

ID	Catalog number	Description	Location	Field number	Maximum preserved length (meters)	Maximum preserved width (meters)	Maximum preserved thickness (meters)
223	BAT 6297	Ceiling planking	Strake 5	B6-1	2.497	0.385	0.060
224	BAT 6298	Platform planking	On BAT 6223 A	A3-1	0.619	0.277	0.070
225	BAT 6299	Frame timber	C32	C32	0.771	0.174	0.172
226	BAT 6300	Frame timber	C32	C32	1.105	0.178	0.174
227	BAT 6301	Wedge	C32	C32	0.616	0.188	0.150
228	BAT 6304	Frame timber	C38	C38	1.414	0.230	0.180
229	BAT 6305	Wedge	C38	C38	0.498	0.186	0.175
230	BAT 6306	Frame timber	C34	C34	1.559	0.186	0.183
231	BAT 6307	Wedge	C34	C34	0.535	0.167	0.145
232	BAT 6308	Frame timber	C36	C36	1.891	0.232	0.174
233	BAT 6309	Frame timber	C40	C40	1.614	0.235	0.175
234	BAT 6310	Wedge	C42	C42	0.365	0.145	0.150
235	BAT 6311	Frame timber	C42	C42	1.956	0.194	0.174
236	BAT 6312	Frame timber	C43	C43	1.177	0.228	0.133
237	BAT 6313	Frame timber	C39	C39	0.762	0.212	0.175
238	BAT 6314	Ceiling planking	Strake 9	B9	2.910	0.385	0.090
239	BAT 6315	Frame timber	C32	C32	1.699	0.205	0.215
240	BAT 6316	Frame timber	C34	C34	1.738	0.181	0.205
241	BAT 6317	Frame timber	C36	C36	2.478	0.275	0.260
242	BAT 6318	Frame timber	C38	C38	2.278	0.232	0.183
243	BAT 6319	Ceiling planking	Strake 6	B6-2	1.875	0.264	0.060
244	BAT 6322	Shelf clamp	Strake 8	B8	2.715	0.428	0.120
245	BAT 6324	Deck beam, lower deck	Shelf clamp, after	A2-1	0.978	0.372	0.273
246	BAT 6325	Ceiling planking	Strake 7	B7	2.554	0.317	0.090
247	BAT 6327	Frame timber	C33	C33	0.997	0.213	—
248	BAT 6328	Wedge	C36	C36	0.453	0.236	0.148
249	BAT 6329	Frame timber	C31	C31	0.572	0.223	—
250	BAT 6330	Frame timber	C37	C37	2.581	0.220	0.189
251	BAT 6331	Frame timber	C37	C37	2.651	0.206	0.175
252	BAT 6332	Frame timber	C35	C35	3.578	0.253	0.185
253	BAT 6333	Frame timber	C33	C33	2.337	0.190	0.175
254	BAT 6336	Frame timber	C31	C31	1.414	0.238	0.195
255	BAT 6337	Frame timber	C31	C31	2.615	0.207	0.195
256	BAT 6338	Frame timber	C33	C33	2.416	0.195	0.175
257	BAT 6339	Frame timber	C39	C39	2.867	0.215	0.195
258	BAT 6340	Frame timber	C41	C41	3.844	0.225	0.165
259	BAT 6341	Frame timber	C41	C41	0.945	0.193	0.204
260	BAT 6342	Frame timber	C40	C40	2.647	0.270	0.235
261	BAT 6344	Frame timber	C43	C43	2.758	0.191	0.165
262	BAT 6345	Frame timber	C44	C44	2.802	0.210	0.165

ID	Catalog number	Description	Location	Field number	Maximum preserved length (meters)	Maximum preserved width (meters)	Maximum preserved thickness (meters)
263	BAT 6346	Frame timber	C45	C45	1.473	0.185	0.155
264	BAT 6347	Cardinal's hat, fragment (joins BATs 6294 and 6348)	Transom	TP13/TP14	—	—	—
265	BAT 6348	Cardinal's hat, fragment (joins BATs 6294 and 6347)	Transom	TP13/TP14	—	—	—
266	BAT 6354	Hull planking	Strake 21	D12	1.127	0.166	0.069
267	BAT 6355	Frame timber	C46	C46	0.717	0.255	0.130
268	BAT 6356	Upper fashion piece	Transom	FP	2.798	0.682	0.238
269	BAT 6357	Standing knee	Transom	FP	1.166	0.768	0.278
270	BAT 6358	Transom beam	Transom	T7	2.175	0.340	0.374
271	BAT 6361	Transom beam	Transom	T1	1.710	0.317	0.358
272	BAT 6364	Transom beam	Transom	T2	2.185	0.332	0.405
273	BAT 6365	Deck transom, lower deck	Transom	T3	1.999	0.364	0.359
274	BAT 6367	Hull planking, inner layer	Strake 3	D-6	2.408	0.328	0.080
275	BAT 6369 A	Frame timber	C39	C39	1.128	0.217	0.195
276	BAT 6369 B	Wing transom	Transom	T8	2.103	0.501	0.483
277	BAT 6370 A	Transom planking, inner layer	Transom	TP12	1.282	0.155	0.090
278	BAT 6370 B	Transom planking, inner layer	Transom	TP13/TP14	1.424	0.423	0.091
279	BAT 6374	Lowest transom	Transom	To	0.796	0.269	0.295
280	BAT 6375	Hull planking, inner layer	Loose find	—	0.811	0.224	0.082
281	BAT 6387	Hull planking, third wale	Strake 19	D10	4.072	0.357	0.193
282	BAT 6388	Hull planking, inner layer	Strake 6	D-3	2.762	0.350	0.087
283	BAT 6389	Hull planking, inner layer	Strake 7	D-2	2.895	0.391	0.077
284	BAT 6390	Hull planking, inner layer	Strake 4	D-5	2.088	0.179	0.086
285	BAT 6391	Hull planking, inner layer	Strake 8	D-1	1.438	0.369	0.070
286	BAT 6392	Hull planking, inner layer	Strake 4	D-5	0.349	0.056	0.089
287	BAT 6393	Hull planking, inner layer	Strake 5	D-4	2.402	0.341	0.090
288	BAT 6394	Hull planking	Strake 20	D11	2.806	0.355	0.125
289	BAT 6395	Hull planking, inner layer	Strake 11	D2	2.922	0.323	0.091
290	BAT 6396	Hull planking, inner layer	Strake 12	D3	2.889	0.279	0.091
291	BAT 6397	Hull planking, first wale	Strake 13	D4	0.962	0.069	0.072
292	BAT 6398	Hull planking, first wale	Strake 13	D4	2.151	0.349	0.129
293	BAT 6399	Hull planking	Strake 15	D6	2.995	0.353	0.124
294	BAT 6400	Hull planking	Strake 18	D9	3.778	0.344	0.122
295	BAT 6401	Hull planking, second wale	Strake 16	D7	3.015	0.361	0.119
296	BAT 6404	Hull planking, first wale	Strake 13	D4	1.332	0.351	0.098
297	BAT 6405	Hull planking	Strake 14	D5	3.030	0.289	0.129

ID	Catalog number	Description	Location	Field number	Maximum preserved length (meters)	Maximum preserved width (meters)	Maximum preserved thickness (meters)
298	BAT 6406	Hull planking	Strake 17	D8	3.573	0.349	0.113
299	BAT 6409	Hull planking, inner layer	Strake 9	Do	2.875	0.396	0.083
300	BAT 6410	Hull planking, inner layer	Strake 10	D1	2.826	0.343	0.093
301	BAT 6411	Hull planking, inner layer	Strake 8	D-1	1.812	0.354	0.084
302	BAT 6412	Transom planking, outer layer	Transom	OP1	1.297	0.224	0.090
303	BAT 6413 A	Transom planking, outer layer	Transom	OP2	1.933	0.410	0.086
304	BAT 6413 B	Transom planking, outer layer	Transom	OP2	0.603	0.313	0.086
305	BAT 6414	Transom planking, inner layer	Transom	TPo	0.910	0.315	0.095
306	BAT 6415	Transom planking, inner layer	Transom	TP1	1.616	0.392	0.094
307	BAT 6416	Transom planking, inner layer	Transom	TP2/TP3	1.594	0.426	0.098
308	BAT 6417 A	Transom planking, outer layer	Transom	OP3	0.996	0.476	0.094
309	BAT 6417 B	Transom planking, outer layer	Transom	OP3	1.010	0.438	0.086
310	BAT 6418	Hull planking, outer layer	Strake 5	OP4	2.084	0.302	0.090
311	BAT 6419 A	Hull planking, outer layer	Strake 6	OP5	1.048	0.224	0.080
312	BAT 6419 B	Hull planking, outer layer	Strake 6	OP5	1.749	0.287	0.071
313	BAT 6420 A	Transom planking, inner layer	Transom	TP5	1.478	0.420	0.094
314	BAT 6420 B	Transom planking, inner layer	Transom	TP6	1.379	0.387	0.094
315	BAT 6420 C	Transom planking, inner layer	Transom	TP7	0.192	0.335	0.094
316	BAT 6421	Transom planking, outer layer	Strakes 6–7	OP6	0.790	0.347	0.091
317	BAT 6422 A	Hull planking, outer layer	Strake 7	OP7	1.122	0.294	0.090
318	BAT 6422 B	Transom planking, outer layer	Transom	OP7	1.314	0.370	0.094
319	BAT 6422 C	Transom planking, outer layer	Transom	OP7	0.489	0.212	0.091
320	BAT 6423	Transom planking, outer layer	Transom	OP8	2.360	0.359	0.091
321	BAT 6425	Transom planking, outer layer	Transom	OP9	1.164	0.397	0.080

ID	Catalog number	Description	Location	Field number	Maximum preserved length (meters)	Maximum preserved width (meters)	Maximum preserved thickness (meters)
322	BAT 6427	Transom planking, inner layer	Transom	TP8/TP9	1.271	0.373	0.090
323	BAT 6428	Transom planking, inner layer	Transom	TP10/TP11	1.154	0.513	0.093
324	BAT 6428 C	Transom planking, outer layer	Transom	OP11	0.779	0.344	0.092
325	BAT 6429	Transom planking, outer layer	Transom	OP10	0.917	0.348	0.084
326	BAT 6433 A	Pine sheathing	Sternpost, port	—	0.406	0.253	0.033
327	BAT 6433 B	Pine sheathing	Sternpost, port	—	0.398	0.619	0.035
328	BAT 6433 C	Cover planking	Sternpost, port	—	0.218	0.084	0.049
329	BAT 6433 D	Cover planking	Sternpost, port	—	0.398	0.449	0.058
330	BAT 6433 E	Copper sheathing	Sternpost, port	—	0.746	0.423	0.003
331	BAT 6434**	Cover planking	Sternpost, port	—	0.403	0.256	0.049
332	BAT 6434	Sternpost	Sternpost	SP3	1.815	0.419	0.528
333	BAT 6435	Cover planking	Sternpost, port	—	0.322	0.193	0.053
334	BAT 6436	Cover planking	Sternpost, port	—	0.418	0.360	0.058
335	BAT 6437	Cover planking	Sternpost, port	—	0.381	0.477	0.058
336	BAT 6438	Cover planking	Sternpost, port	—	—	—	—
337	BAT 6439	Cover planking	Sternpost, port	—	0.353	0.183	0.058
338	BAT 6441 A	Pine sheathing	Transom	TSK1	1.132	0.150	0.040
339	BAT 6441 B	Pine sheathing	Transom	TSK2	1.703	0.540	0.040
340	BAT 6444	Fashion piece	Transom	FP	4.608	0.600	0.320
341	BAT 6445 A	Transom planking, inner layer	Transom	TP15	1.183	0.283	0.100
342	BAT 6445 B	Transom planking, inner layer	Transom	TP16	0.631	0.379	0.104
343	BAT 6451	Pine sheathing	Transom, unknown	—	1.030	0.230	0.032
344	BAT 6452	Pine plank	Transom, unknown	—	0.870	0.210	0.032
345	BAT 6454	Pine plank	Transom, unknown	—	1.070	0.170	0.022
346	BAT 6482	Pine sheathing	Transom, unknown	—	0.970	0.220	0.032
347	BAT 6483	Pine sheathing (4 fragments)	Transom, unknown	—	2.020	0.310	0.028
348	BAT 6484	Pine sheathing	Transom, unknown	—	1.600	0.280	0.032
349	BAT 6485	Pine sheathing	Transom, unknown	—	1.050	0.220	0.032
350	BAT 6486	Pine sheathing	Transom, unknown	—	1.080	0.310	0.032
351	BAT 6487	Pine sheathing (3 fragments)	Transom, unknown	—	—	—	—
352	BAT 6501	Pine sheathing	Transom, unknown	—	0.825	0.085	0.039
353	BAT 6513	Frame timber	C11	C11	0.710	0.210	0.170
354	BAT 80104	Gudgeon concretion	Sternpost	—	—	—	—

ID	Catalog number	Description	Location	Field number	Maximum preserved length (meters)	Maximum preserved width (meters)	Maximum preserved thickness (meters)
355	BAT 80041	Gun port hinge concretion	Sternpost	—	—	—	—
356	BAT 80395	Gudgeon concretion	Sternpost	—	0.360	0.155	0.055
357	BAT 80395 R	Cast from gudgeon concretion	Sternpost	—	0.360	0.155	,0.055

* Number 6260 was accidentally given to two timbers.

** Number 6434 was accidentally given to two timbers: cover planking on the port sternpost and the sternpost itself.

APPENDIX C

TERMINOLOGY FOR DENDROCHRONOLOGICAL RESEARCH

ELSEMIEKE HANRAETS

SPECIES

Wood species are identified solely for the purpose of dendrochronological dating. Usually only the genus (i.e., *Quercus* sp. or *Pinus* sp.) is listed, unless it is known or obvious in some way what species the wood is.

PITH

Number of rings missing from the sample (or the measured tree ring series) up to the very first (oldest) ring that was formed by the tree.

SAPWOOD

Number of sapwood rings that were measured. The average number of sapwood rings in oak is 16 ± 5 for a tree of up to 100 years old, 20 ± 6 for a tree of between 100 and 200 years old, and 26 ± 8 for a tree of more than 200 years old.¹ In oaks from the Baltic region, the average number of sapwood rings is somewhat lower than in oaks from western Europe: $15 (+8/-6)$.² Scots pine (*Pinus sylvestris*) has clearly visible sapwood, but an estimation of the felling date is not possible as the number of sapwood rings varies too much. Norway spruce (*Picea abies*) and silver fir (*Abies alba*) have no sapwood. Of course, the presence of the wood wane/edge, or *waney edge*, on a sample always gives the exact year of felling.

WOOD EDGE

Estimated number of rings up to the wood/waney edge or last-formed tree ring (directly under the bark) necessary to obtain the true felling date.

FELLING DATE

The year in which a tree was felled. An absolute date for the felling of the tree can be given only if the waney edge on the sample is present. When sapwood is present (or when the sapwood border is visible), the felling date can be calculated. For example, when a sample of an oak of between 100 and 200 years old (with an average of 20 ± 6 sapwood rings) contains 4 sapwood rings, the average number of sapwood rings missing is 16 ± 6 . This number is added to the date of the last/youngest measured ring. If no sapwood rings are present on the sample, the number of missing heartwood rings is unknown. The felling date of that particular tree is an *unknown* number of years after the date of the youngest ring on the sample plus the estimated number of missing sapwood rings.

N

Total number of rings on the sample.

%PV

Gleichlaufigkeit (German) or percentage of parallel variation (English). Percentage of rings in the ring pattern of the sample and the chronology, which show an identical increase or decrease in ring width at the given position. Whether this value is meaningful depends on the length of the overlap between the series.

T

The value resulting from a student's t-test on the cross-correlation between the sample and the chronology.

P

The possibility (as a fraction of 1) that the value for %PV is coincidental and not a valid date.

NLARTPO1

Chronology for oak from the Baltic region based on Dutch panel paintings.³

NOTES

CHAPTER 1

1. Francisco Pelsaert mentions in his journal that the ship set sail on 28 October 1628, which is correct. However, the ship ran aground immediately, and it took one day to get the ship afloat again. Hence, its official day of departure is one day later on 29 October 1628. Bruijn, Gaastra, and Schöffer, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, vol. 2, no. 0372.1 (the numbers refer to a specific voyage made by one ship); Pelsaert, *Ongeluckige voyage*, 1; and Roeper, *De schipbreuk van de Batavia*, 15.

2. Roeper, *De schipbreuk van de Batavia*, 12.

3. Bruijn, Gaastra, and Schöffer, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, vol. 2, nos. 0372.1, 0746.1, 1055.1, 1150.2, 4260.1, 4368.2; and vol. 3, nos. 5571.1, 7986.1, 8077.2.

4. Pelsaert incorrectly mentions in his journal that at the beginning of its journey *Batavia* sailed with only two other ships, *Dordrecht* and *Assendelft*. He also refers to *Assendelft* as a yacht, not a flute. Pelsaert, *Ongeluckige voyage*, 1–2. Vibeke Roeper refers to *Zaandam* as a yacht rather than a flute. Roeper, *De schipbreuk van de Batavia*, 15.

5. Mostert, “Chain of Command,” 38.

6. *Ibid.*, 38.

7. Tristan Mostert, letter to author, 16 January 2008.

8. Bruijn, Gaastra, and Schöffer, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, vol. 2, nos. 0366.1, 0367.1, 0368.1, 0369.5, 0370.1, 0371.1, 0372.1.

9. *Ibid.*

10. *Ibid.*, no. 0453.2.

11. Roeper, *De schipbreuk van de Batavia*, 15.

12. Sigmond and Zuiderbaan, *Dutch Discoveries of Australia*, 31–35.

13. Bruijn, Gaastra, and Schöffer, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, vol. 2, nos. 0143.3, 0144.2; and Sigmond and Zuiderbaan, *Dutch Discoveries of Australia*, 32.

14. Kooijmans and Schooneveld-Oosterling, *VOC Glossarium*. One Dutch or German mile (*mijl*) = 7.407 km.

15. Green, *Australia's Oldest Wreck*, 1–2, 15–16, 18–19.

16. Sigmond and Zuiderbaan, *Dutch Discoveries of Australia*, 19–26.

17. At the moment of *Batavia*'s wrecking, 323 people were aboard the ship, and approximately 30 did not survive. Roeper, *De schipbreuk van de Batavia*, 20, 20–21, 24–28.

18. For an overview, see *ibid.*, 9.

19. Drake-Brockman, “Reports of Francisco Pelsaert,” 15.

20. *Ibid.*, 1–18; and Drake-Brockman, *Voyage to Disaster*,

97–240. This book uses the transcript of Pelsaert's journal and compilation of seventeenth-century documents on the *Batavia* shipwrecking by Vibeke Roeper, *De schipbreuk van de Batavia*, 1629, because it is the most complete and thoroughly researched work printed in its original language.

21. Green, “The VOC Ship *Batavia* Wrecked in 1629,” 43–63; and Green, “Planking-First Construction of the VOC Ship *Batavia*,” 70.

22. Green, *Loss of the Verenigde Oostindische Compagnie Retourschip Batavia*.

23. Generally, Dutch ships destined for long-distance journeys were much smaller than those of the Spanish, Portuguese, and English until the end of the sixteenth century, after which their size increased steadily. Elias, *De vlootbouw in Nederland*, 7; and Keuning, *De tweede schipvaart der Nederlanders naar Oost-Indië*, lvii.

24. Most of the ships of the English East India Company made only four voyages to the Indies and rarely served for more than 10 years. The VOC, on the other hand, used its vessels for round-trip voyages as long as the ships were able to function, after which they were usually deployed for the intra-Asiatic trade. Bruijn, Gaastra, and Schöffer, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, 1:95, 38–39.

25. Three full or continuous decks generally did not come into use until the eighteenth century. *Ibid.*, 48.

26. See also the online version of Bruijn, Gaastra, and Schöffer, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, <http://resources.huygens.knaw.nl/das>.

CHAPTER 2

1. Hocker, “Bottom-Based Shipbuilding in Northwestern Europe,” 80.

2. Van Beylen, *Schepen van de Nederlanden*, 7.

3. Hocker, “Bottom-Based Shipbuilding in Northwestern Europe,” 80.

4. Ypey, “Wrak van een laat-zestiende-eeuws spiegeljacht,” 64.

5. Overmeer, “Searching for the Missing Link?,” 67.

6. *Ibid.*, 63–72.

7. Alice Overmeer, letter to author, 6 February 2006.

8. Hocker, “Bottom-Based Shipbuilding in Northwestern Europe,” 65–67.

9. R. Unger, “The *Fluit*,” 124.

10. Hocker, “Bottom-Based Shipbuilding in Northwestern Europe,” 29–74, 84, 81, 80, 80–81, 84.

11. The annual forest area needed to build ships, including inland-water ships, was 450,000 m³ (3,500 hectares). Porsius and De Munck, "Over hout, de herkomst, de kwaliteitseisen en de bewerking daarvan," 147–48; and Porsius, "Hout en schepen," 10.
12. Schillemans, *De houtveilingen van Zaandam in de jaren 1655–1811*, 5, 9, 17.
13. Porsius and De Munck, "Over hout, de herkomst, de kwaliteitseisen en de bewerking daarvan," 137.
14. Eckstein, Van Es, and Hollstein, "Beitrag zur Datierung der frühmittelalterlichen Siedlung Dorestad, Holland," 165–75; and Wazny, "Origin, Assortments and Transport of Baltic Timber," 115.
15. Wazny, "Origin, Assortments and Transport of Baltic Timber," 116.
16. Bruijn, "The Timber Trade," 123–35; Porsius and De Munck, "Over hout, de herkomst, de kwaliteitseisen en de bewerking daarvan," 148; and Porsius, "Hout en schepen," 11.
17. J. Kingma, "De wereld van hout en mechanische zagerij," 66; and Porsius and De Munck, "Over hout, de herkomst, de kwaliteitseisen en de bewerking daarvan," 140–42.
18. J. Kingma, "De wereld van hout en mechanische zagerij," 66–67; Porsius, "Hout en schepen," 13; and Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 37.
19. Hocker, "Bottom-Based Shipbuilding in Northwestern Europe," 84.
20. Dobber and Paul, *Cornelis Corneliszoon van Uitgeest*, 206; and J. Kingma, "De wereld van hout en mechanische zagerij," 81.
21. Dobber and Paul, *Cornelis Corneliszoon van Uitgeest*, 205.
22. V. Kingma, "De betekenis van de uitvindingen van Cornelis Corneliszoon voor de Nederlandse nijverheid," 133.
23. Honig, "De molens van Amsterdam," 95.
24. Ibid., 95–96.
25. Ibid., 96.
26. V. Kingma, "De betekenis van de uitvindingen van Cornelis Corneliszoon voor de Nederlandse nijverheid," 133; and Porsius, "Hout en schepen," 11.
27. Schillemans, *De houtveilingen van Zaandam in de jaren 1655–1811*, 11.
28. V. Kingma, "De betekenis van de uitvindingen van Cornelis Corneliszoon voor de Nederlandse nijverheid," 133.
29. Ibid., 133–34.
30. Van Dillen, *Bronnen tot de geschiedenis van het bedrijfsleven en het gildewezen van Amsterdam*, 2:694–96 (no. 1250), 716–17 (no. 1284), 721–22 (no. 1292).
31. V. Kingma, "De betekenis van de uitvindingen van Cornelis Corneliszoon voor de Nederlandse nijverheid," 134.
32. Van Dillen, *Bronnen tot de geschiedenis van het bedrijfsleven en het gildewezen van Amsterdam*, 3:182–83 (no. 355).
33. Bonke, "Van Amsterdam tot Japara," 157–58.
34. Hocker, "Bottom-Based Shipbuilding in Northwestern Europe," 84.
35. Wegener Sleeswyk, *De Gouden Eeuw van het fluitschip*, 39.
36. Lemée, *Renaissance Shipwrecks from Christianshavn*, 262.
37. Wegener Sleeswyk, *De Gouden Eeuw van het fluitschip*, 39.
38. R. Unger, "The Fluit," 121; and Wegener Sleeswyk, *De Gouden Eeuw van het fluitschip*, 40.
39. Tolls or dues had to be paid to the Danish Crown by all ships passing through the Danish Sound, the narrow waterway between Denmark and Sweden. Wegener Sleeswyk, *De Gouden Eeuw van het fluitschip*, 9, 18.
40. Ibid., 29–35.
41. Ibid., 17–19, 17, 9, 69–71.
42. Barbour, "Dutch and English Merchant Shipping," 275.
43. R. Unger, "The Fluit," 125.
44. Scammell, *The World Encompassed*, 427.
45. Wegener Sleeswyk, *De Gouden Eeuw van het fluitschip*, 27.
46. Kroum Batchvarov, letter to author, 20 March 2012.
47. Wegener Sleeswyk, *De Gouden Eeuw van het fluitschip*, 27.
48. R. Unger, "The Fluit," 122.
49. Manders, "The BZN 10-Wreck," 101.
50. R. Unger, "The Fluit," 122.
51. Wegener Sleeswyk, *De Gouden Eeuw van het fluitschip*, 25–26.
52. Bruijn, "The Timber Trade," 124; and Wegener Sleeswyk, *De Gouden Eeuw van het fluitschip*, 26–27.
53. Van Linschoten, *Reizen van Jan Huyghen van Linschoten naar het Noorden*.
54. L'Honoré Naber, *Reizen van Willem Barents*; and Hoving and Emke, *Het schip van Willem Barents*, 15.
55. Rouffaer and IJzerman, *De Eerste Schipvaart der Nederlanders naar Oost-Indië* (1915); and Rouffaer and IJzerman, *De Eerste Schipvaart der Nederlanders naar Oost-Indië* (1925).
56. Bruijn, Gaastra, and Schöffner, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, 1:3.
57. Gaastra, *The Dutch East India Company*, 16.
58. Ibid., 17, 19.
59. Keuning, *De tweede schipvaart der Nederlanders naar Oost-Indië* (1938); Keuning, *De tweede schipvaart der Nederlanders naar Oost-Indië* (1940); and Keuning, *De tweede schipvaart der Nederlanders naar Oost-Indië* (1947).
60. Gaastra, *The Dutch East India Company*, 20–21, 21, 23.
61. Elias, *De vlootbouw in Nederland*, 7; and Keuning, *De tweede schipvaart der Nederlanders naar Oost-Indië* (1938), lvii.
62. Elias, *Schetsen uit de geschiedenis van ons zeewezen*.
63. This calculation was based on the ships listed in Bruijn, Gaastra, and Schöffner, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, vols. 2, 3.
64. Perry Moree, *Dodo's en galjoenen*, 166.

65. Van Beylen, *Schepen van de Nederlanden*, 10–11.
66. *Pinasses* were small warships used by the Dutch Admiralties in the late sixteenth century. Sometimes yachts were referred to as *pinasses* as well. The name was used in the Netherlands in the seventeenth century for heavily armed vessels, which became larger over time. Parthesius, “Dutch Ships in Tropical Waters,” 75.
67. Keuning, *De tweede schipvaart der Nederlanders naar Oost-Indië* (1938), lvii; and Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 456.
68. Oars were occasionally used even for ships up to 300 tons. Coen, *Bescheiden omtrent zijn bedrijf in Indië*, 4:316; and Parthesius, “Dutch Ships in Tropical Waters,” 75.
69. Parthesius, “Dutch Ships in Tropical Waters,” 59.
70. *Ibid.*
71. Wagenaar, “Het eiland Onrust bij Batavia als onderdeel van het VOC-scheepsbedrijf,” 65.
72. Parthesius, “Dutch Ships in Tropical Waters,” 65.
73. Rietbergen, *De eerste landvoogd Pieter Both*, 2:222–23.
74. Parthesius, “Dutch Ships in Tropical Waters,” 60.
75. The development of the different types of ships used by the VOC has been discussed in detail by Robert Parthesius in *ibid.*, 59–85.
76. Bruijn, Gaastra, and Schöffner, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, 1:478–79.
77. Ypey, “Wrak van een laat-zestiende-eeuws spiegeljacht,” 65.
78. Marquardt, “The *Duyfken* Enigma,” 41–57.
79. De Jong, “Comment: Back to Square One,” 3–15; and Burningham, “Round Sterns and Circular Arguments,” 16–28.
80. Van Linschoten, *Reizen van Jan Huyghen van Linschoten naar het Noorden*, plates by 38, 72, 296.
81. IJzerman, *De Reis om de Wereld door Olivier van Noort*, title page, 12, 62, 120.
82. Baker, *Fragments of Ancient English Shipwreight*; Barker, “Many May Peruse Us,” 539–59, and “Fragments of the Pepysian Library,” 161–78; Fennis, *Manuel de construction des galères*; Furttenbach, *Architectura martialis*; and Salisbury and Anderson, *Treatise on Shipbuilding*.
83. Hoving and Emke, *Het schip van Willem Barents*, 117–20.
84. This ship was presumably built according to a Dutch foot measure used by one of the towns in the Zeeland region, such as Middelburg (0.299 m), Vlissingen (0.301 m), or Veere (0.306 m). Cor Emke, letter to author, 23 April 2008.
85. Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 450–553.
86. Parthesius, “Dutch Ships in Tropical Waters,” 60.
87. Bruijn, Gaastra, and Schöffner, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, 1:38.
88. National Archives (NA) of the Netherlands, Verenigde Oostindische Compagnie, 1602–1795, item no. 229 (Resoluties van de ordinaris en extraordinaris vergaderingen van de kamer Amsterdam, 6 January 1622–31 December 1629), 18 November 1627.
89. Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 462–63, 464.
90. NA, Verenigde Oostindische Compagnie, item no. 230 (Minuut- en net-resoluties van de ordinaris en extraordinaris vergaderingen van de kamer Amsterdam, 1623–31), 8 December 1631; and Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 464.
91. Parthesius, “Dutch Ships in Tropical Waters,” 167.
92. Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 464.
93. Coolhaas, *Generale missiven van gouverneurs-generaal en raden aan Heren XVII*, 1:478–79.
94. Matelief de Jonge, “Historische verhael vande treffelijcke reyse,” 186.
95. Harris, *F. H. Chapman*, 9; and Steffy, *Wooden Ship Building*, 142.
96. Barker, “Many May Peruse Us,” 539–59.
97. Kroum Batchvarov, letter to author, 20 March 2012.
98. Barker, “Many May Peruse Us,” 539–59.
99. Kroum Batchvarov, letter to author, 20 March 2012.
100. R. Unger, *Dutch Shipbuilding before 1800*, 109–15; and Harris, *F. H. Chapman*, 13.
101. Baker, *Fragments of Ancient English Shipwreight*; Bushnell, *The Compleat Shipwright*; and Salisbury and Anderson, *Treatise on Shipbuilding*.
102. Barker, “Many May Peruse Us,” 545–46, and “Fragments of the Pepysian Library,” 165–70.
103. Barker, “Fragments of the Pepysian Library,” 162.
104. Abell, *The Shipwright’s Trade*, 32–38; and Steffy, *Wooden Ship Building*, 142.
105. Abell, *The Shipwright’s Trade*, 28–38; and Steffy, *Wooden Ship Building*, 142–45.
106. Witsen, *Architectura navalis et reginem nauticum*, 168–70.
107. Hoving, *Nicolaes Witsens scheeps-bouw-konst open gestelt*, 58–61.
108. Witsen, *Architectura navalis et reginem nauticum*, 170.
109. Hoving and Parthesius, “Hollandse scheepsbouw-methoden in de zeventiende eeuw,” 7–8.
110. Witsen, *Architectura navalis et reginem nauticum*, 170.
111. Hoving, “Dutch Shipbuilding in the Seventeenth Century,” 29.
112. Witsen, *Architectura navalis et reginem nauticum*, 210–39, 340.
113. *Ibid.*, 94–177.
114. Hoving, *Nicolaes Witsens scheeps-bouw-konst open gestelt*, 22–23.

115. Witsen, *Architectura navalis et reginem nauticum*, 94.
116. Ibid., 165–68, 164, 165, 165–68, 167.
117. Ibid., 169.
118. Ibid.
119. Hoving and Parthesius, “Hollandse scheepsbouw-methoden in de zeventiende eeuw,” 7.
120. Remnants of nail plugs are found on the hull planking of the Scheurrak T24 (post-1655), Inschot/Zuidoostrak (early seventeenth century), and Oostflevoland B71 (1614–19) ships. Hocker, “Bottom-Based Shipbuilding in Northwestern Europe,” 83; Maarleveld, *Archaeological Heritage Management in Dutch Waters*, 116–17, 127–29; and Maarleveld, Goudswaard, and Oosting, “New Data on Early Modern Dutch-Flush Shipbuilding,” 20, 22–24.
121. Witsen also mentions that in Sweden planks are boiled to bend them more easily. Witsen, *Architectura navalis et reginem nauticum*, 170, 334, 169.
122. Hocker, “Bottom-Based Shipbuilding in Northwestern Europe,” 83–84.
123. Witsen, *Architectura navalis et reginem nauticum*, 170.
124. Hoving and Parthesius, “Hollandse scheepsbouw-methoden in de zeventiende eeuw,” 8.
125. Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 69–70.
126. Ibid., 77–78; and Parthesius, “De Batavia, een retourschip van de VOC,” 81.
127. For information on the Noorderkwartier, see Van der Woude, *Het Noorderkwartier*, 1:19–30.
128. Hocker, “Bottom-Based Shipbuilding in Northwestern Europe,” 83.
129. Parthesius, “De Batavia, een retourschip van de VOC,” 81.
130. Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 69.
131. Ibid., 71, 75, 77, 78–79.
132. Hoving, “Drawing the Line,” 71.
133. Mostert, “Chain of Command,” 54.
134. NA, Admiraliteitscolleges, item no. 1360; Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 450; and Parthesius, “De dubbele huid van Oostindievaarders aan het begin,” 26.
135. Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 453.
136. Parthesius, “Dutch Ships in Tropical Waters,” 167.
137. Coen, *Bescheiden omtrent zijn bedrijf in Indië*, 2:109 (14 May 1616).
138. Hans Bonke, “Het eiland Onrust,” 49; Coen, *Bescheiden omtrent zijn bedrijf in Indië*, 1:581, 2:109; Coolhaas, *Generale missiven van gouverneurs-generaal en raden aan Heren XVII*, 2:481; Heeres, *Dagh-register gehouden int Casteel Batavia*, 164, 260; and Van Opstall, *De reis van de vloot van Pieter Willemsz Verhoeff naar Azië*, 125.
139. Heeres, *Dagh-register gehouden int Casteel Batavia*, 5, 16, 48, 325, 260.
140. NA, Verenigde Oostindische Compagnie, item no. 100 (Kopie-resoluties van de Heren XVII, 1608–23), folio 169, point 13, 14 November 1611.
141. Ibid., folio 148, 1611.
142. Voorbeijtel Cannenburg, *De reis om de wereld van de Nassausche vloot*, 20–21. Two ship’s carpenters and two carpenter’s mates were enlisted on the VOC ship *Haarlem*, one ship’s carpenter and three carpenter’s mates were enlisted on the VOC ship *Oosterland* on its voyage to the Indies in 1695, and three ship’s carpenters on its voyage of 1696. However, on its homeward voyage of 1693 more than six carpenters were aboard the ship. Werz, “*Een bedroefd, en beclaaglijck ongeval*,” 187–96, and *Diving up the Human Past*, 202.
143. Coolhaas, *Generale missiven van gouverneurs-generaal en raden aan Heren XVII*, 2:481.
144. Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 453.
145. Ibid.
146. Wagenaar, “Het eiland Onrust bij Batavia als onderdeel van het VOC-scheepsbedrijf,” 68.
147. It is not known whether they were built according to the Amsterdam, Rotterdam, or another Dutch foot measure.
148. NA, Verenigde Oostindische Compagnie, item no. 99 (Kopie-resoluties van de Heren XVII, 1602–7), folio 145, September 1604.
149. May, *De reis van Jan Cornelisz*, xlviii, 46–53.
150. Van den Broecke, *Pieter van den Broecke in Azië*, 62. Frigates were small open boats rigged with two lateen sails.
151. Witsen, *Architectura navalis et reginem nauticum*, 199.
152. Coen, *Bescheiden omtrent zijn bedrijf in Indië*, 7:628–29.
153. Witsen, *Architectura navalis et reginem nauticum*, 175–76, 176–77.
154. Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 287–99, 299, 287.
155. Bruijn, Gaastra, and Schöffner, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, 1:27.
156. Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 453.
157. Bruijn, Gaastra, and Schöffner, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, 1:28.
158. NA, Verenigde Oostindische Compagnie, item no. 99 (Kopie-resoluties van de Heren XVII, 1602–7), folio 146, September–December 1604; and Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 450.

In the VOC archives, *Amsterdam* is listed as a ship of approximately 1,000 tons; *Mauritius*, approximately 800 tons; and *Witte Leeuw*, approximately 600 tons. This is an estimate provided at the time of purchase by the VOC. When the three ships were refitted and set sail to the Indies, the VOC archives and the first page of the journal of the journey under Commander Cornelis Matelief de Jonge listed the ships more accurately as 700, 700, and 540 tons, respectively. See NA, Verenigde Oostindische Compagnie, item no. 99 (Kopie-resoluties van de Heren XVII, 1602–7), folio 161; and Matelief de Jonge, “Historische verhael vande treffelijke reyse,” 1.

159. NA, Verenigde Oostindische Compagnie, item no. 99 (Kopie-resoluties van de Heren XVII, 1602–7), folio 146 (September–December 1604).

160. Bruijn, Gaastra, and Schöffer, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, 1:95.

161. Coen, *Bescheiden omtrent zijn bedrijf in Indië*, 4:52–54.

CHAPTER 3

1. Green, *Loss of the Verenigde Oostindische Compagnie Retourschip Batavia*, 45, 104; and Geoff Kimpton, memorandum to Jeremy Green, 1 November 1999 (Maritime Archaeology Archive, Western Australian Museum, MA74/74).

2. Hundley, “*Batavia* Reconstruction,” 249.

3. Roeper, *De schipbreuk van de Batavia*, 212.

4. *Ibid.*, 90.

5. *Ibid.*, 191.

6. *Ibid.*, 90. The phrase *d’achter windtveeringh* in this passage has been translated by Henrietta Drake-Brockmann as “bulwark” but should have been the “upper fashion piece” or “stern quarter.” Additionally, the word *kruijspoorte* is the gun port at the mizzen-mast, not the gunners’ room. See Drake-Brockman, *Voyage to Disaster*, 134.

7. Roeper, *De schipbreuk van de Batavia*, 175.

8. Ghisalberti et al., “Analysis of Acid-Affected *Batavia* Timbers,” 281, 281–83.

9. Baker and Green, “Recording Techniques Used during the Excavation of the *Batavia*,” 146.

10. *Ibid.*, 143–58; Green, *Loss of the Verenigde Oostindische Compagnie Retourschip Batavia*, and “The VOC Ship *Batavia* Wrecked in 1629,” 43–63; and Ingelman-Sundberg, “The VOC Ship *Batavia* 1629,” 45–53.

11. *Batavia Daybook* 1; *Batavia Daybook* 2.

12. *Batavia Daybook* 2; *Batavia Daybook* 3.

13. *Batavia Daybook* 4; *Batavia Daybook* 5, 1–28.

14. *Batavia Daybook* 5, 8 April 1975, 28, 44.

15. Ghisalberti et al., “Analysis of Acid-Affected *Batavia* Timbers,” 281–307; MacLeod, “Conservation of Waterlogged Timbers

from the *Batavia* 1629,” 1–8; Pang, “Treatment of Waterlogged Timbers from a 17th Century Dutch East Indiaman *Batavia*,” 1–6; Richards, “Consolidation of Degraded Deacidified *Batavia* Timbers,” 35–52, and “Cosmetic Treatment of Deacidified *Batavia* Timbers,” 12–13.

16. Green, *Loss of the Verenigde Oostindische Compagnie Retourschip Batavia*; and Baker and Green, “Recording Techniques Used during the Excavation of the *Batavia*,” 143–58.

17. Baker and Green, “Recording Techniques Used during the Excavation of the *Batavia*,” 144.

18. Vicki Richards, letter to author, 28 February 2008.

19. D-7 and D-8 were labeled as such in the field but should actually have been labeled E-7 and E-8. When the strakes were raised, they turned out to be part of the outer layer of hull planking, as the inner layer had completely eroded away.

20. Baker and Green, “Recording Techniques Used during the Excavation of the *Batavia*,” 147–48.

21. *Ibid.*, 149, 146, 150.

22. MacLeod, “Conservation of Waterlogged Timbers from the *Batavia* 1629,” 1.

23. Baker and Green, “Recording Techniques Used during the Excavation of the *Batavia*,” 151.

24. *Ibid.*, 153.

25. Hundley, “*Batavia* Reconstruction,” 254.

26. *Ibid.*

27. *Ibid.*

28. *Ibid.*

29. *Ibid.*, 254–55.

30. *Ibid.*, 255.

31. Baker and Green, “Recording Techniques Used during the Excavation of the *Batavia*,” 149.

32. MacLeod, “Conservation of Waterlogged Timbers from the *Batavia* 1629,” 5; and Pang, “Treatment of Waterlogged Timbers from a 17th Century Dutch East Indiaman, *Batavia*,” 5.

33. Bill Leonard is best known as the shipwright of the reconstructions of the VOC yacht *Duifje*, built in the late 1990s, and HM Bark *Endeavour*, built in the late 1980s. Both reconstructions were built in Fremantle, Australia.

CHAPTER 4

1. NA, Verenigde Oostindische Compagnie, item no. 147 (Resoluties van de ordinarij en extraordinarij vergaderingen van de Heren XVII, 1611–30), 29 March 1626.

2. *Ibid.*; Porsius and De Munck, “Over hout, de herkomst, de kwaliteitseisen en de bewerking daarvan,” 146; Witsen, *Architectura navalis et regimē nauticum*, 133; and Van IJk, *De Nederlandse scheeps-bouw-konst open gestelt*, 168.

3. NA, Verenigde Oostindische Compagnie, item no. 229

(Resoluties van de ordinaris en extraordinaris vergaderingen van de kamer Amsterdam, 1622–29), 29 June 1628.

4. Bruijn, Gaastra, and Schöffer, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, 1:37–38, 27.

5. NA, Verenigde Oostindische Compagnie, item no. 229 (Resoluties van de ordinaris en extraordinaris vergaderingen van de kamer Amsterdam, 1622–29), 18 November 1627 and 25 May 1628.

6. Tristan Mostert and Lodewijk Wagenaar, letter to author, 5 February 2008.

7. NA, Verenigde Oostindische Compagnie, item no. 229 (Resoluties van de ordinaris en extraordinaris vergaderingen van de kamer Amsterdam, 1622–29), 29 June 1628.

8. Ibid., item no. 147 (Resoluties van de ordinaris en extraordinaris vergaderingen van de Heren XVII, 29 June 1611–27 August 1630), 18 July 1628.

9. Ibid., item no. 7345 (Kopie-resoluties van de ordinaris en extraordinaris vergaderingen van de Heren XVII, Kamer Zeeland, 25 April 1623–22 November 1631), point 8, 18 July 1628.

10. Ibid., item no. 147 (Resoluties van de ordinaris en extraordinaris vergaderingen van de Heren XVII, 1611–30), point 7, July 1628.

11. Ibid., item no. 229 (Resoluties van de ordinaris en extraordinaris vergaderingen van de kamer Amsterdam, 1622–29), August–October 1628.

12. Ibid., item no. 147 (Resoluties van de ordinaris en extraordinaris vergaderingen van de Heren XVII, 1611–30), 29 March 1626; and item no. 7345 (Kopie-resoluties van de ordinaris en extraordinaris vergaderingen van de Heren XVII, Kamer Zeeland, 25 April 1623–22 November 1631), point 8, 18 July 1628..

13. Ibid., item no. 147 (Resoluties van de ordinaris en extraordinaris vergaderingen van de Heren XVII, 1611–30), 29 March 1626.

One last = 4,000 Amsterdam lb (1,976 kg). For convenience's sake, one last is then considered to be about 2 metric tons. This conversion can be applied to VOC ships only until 1636, after which the *lasten* of a ship no longer have any meaning, as the VOC kept the figures artificially low for fiscal reasons. From 1636 onward, the volume was calculated based on the measurements of the ship. The volume in *lasten* was calculated by a simple formula (length × breadth × depth in Amsterdam feet ÷ 200). For more information on this method and the problems regarding the ships' volumes, see Bruijn, Gaastra, and Schöffer, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, 1:42–44.

14. Bruijn, Gaastra, and Schöffer, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, 1:38.

15. Green, "Planking-First Construction of the VOC Ship *Batavia*," 70.

16. These nail plugs were initially observed by Thijs Maarleveld, Institute of History and Civilization, Center for Maritime and Regional Studies, University of Southern Denmark. Maarleveld, *Archaeological Heritage Management in Dutch Waters*, 126.

17. In 1779, the VOC's master shipwright Willem Udemans and ship's surgeon Ezechiël Lombard convincingly managed to explain in a letter to the VOC Chamber of Zeeland the technological and medical advantages of three-decked ships. As a result, the VOC finally decided to connect the quarterdeck and the forecabin deck by adding walkways (also called a spar deck) along either side of the waist or by decking this open area. This connection was mainly a social breakthrough, as it coupled the officers' quarters with those of the crew, a change that not everyone appreciated. This advancement did not lead to the construction of a true three-decker, as generally no cannon were placed on the walkways or the connecting deck. The same can be said about the three-deckers constructed by Dutch Admiralties. Bruijn, Gaastra, and Schöffer, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, 1:48–49; and Hoving and Lemmers, *In tekening gebracht*, 111–12.

18. Bruijn, Gaastra, and Schöffer, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, 1:48.

19. Roeper, *De schipbreuk van de Batavia*, 49–52.

20. Bronze cannon were expensive and, generally, placed in areas only in the direct vicinity of the compass (on the quarterdeck fore of the cabin). Two bronze Rotterdam Admiralty cannon, BAT 3640 and BAT 3627, and two composite cannon, BAT 3742 and BAT 3641, were recovered in *Batavia's* stern area, whereas the three remaining bronze cannon, BAT 3637, BAT 3638, and BAT 3639, were found in the bow area. The first is a Rotterdam Admiralty cannon, and the latter two were Amsterdam Admiralty cannon. It is likely that the bronze cannon, recovered by Pelsaert, was the counterpart for the Rotterdam Admiralty cannon in the ship's bow. Green, *Loss of the Verenigde Oostindische Compagnie Retourschip Batavia*, 25–54.

21. Roeper, *De schipbreuk van de Batavia*, 219. The conversion is 1 Amsterdam lb = 0.494 kg. See Glamann, *Dutch-Asiatic Trade 1620–1740*, 304.

22. Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 507.

23. Bruijn, Gaastra, and Schöffer, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, vol. 2, nos. 0553.1, 0593.2, 0643.3, 0696.4, 0734.5, 0737.1, 0772.6, 0796.2, 0829.7, 0850.3, 0897.4, 0950.5, 1004.6; and vol. 3, nos. 5290.1, 5320.2, 5343.3, 5377.4, 5400.5, 5402.1, 5414.6, 5426.2, 5456.3, 5475.4, 5505.5.

24. All average measurements listed in this chapter have been taken from the original edges of the timbers. Hull planks, for example, that are eroded below their original surfaces are omitted for calculating average dimensions.

25. This plank was raised in sections and comprises BAT 6409, BAT 6204, BAT 6077, BAT 6086 A, BAT 6087, and BAT 6031.

26. Green, “Planking-First Construction of the VOC Ship *Batavia*,” 70.

27. Steffy, *Wooden Ship Building*, 281.

28. This drop strake consists of timber sections BAT 6390, BAT 6192, and BAT 6184.

29. Van de Moortel, *A Cog-like Vessel from the Netherlands*, 51–52.

30. McCarthy, *Ships’ Fastenings*, 66–68; and Lemée, *Renaissance Shipwrecks from Christianshavn*, 205.

31. McCarthy, *Ships’ Fastenings*, 68, fig. 40.

32. Adriaan de Jong, conversation with author, 21 April 2007.

33. The wale comprises timber sections BAT 6387 and BAT 6176.

34. The word *spijkerpennen* has been translated by Christian Lemée as “spike plugs.” The use of the word *spike* to define spike plugs is, however, problematic. In general, there has been quite some discussion on what size a nail needs to be for it to be called a true spike. Although the *International Maritime Dictionary* states that the length at which nails become spikes is approximately 3 in (7.5 cm), some authors, including Michael McCarthy, prefer to categorize large square-sectioned nails longer than 4 in (10 cm) as spikes.

As fasteners of the temporary cleats are no longer present, it is not known how long the nails or spikes would have been, although they probably did not exceed 4 in. Their size certainly does not correspond to the cross-sectional size of the spikes used to fasten the outer layer to the inner layer of hull planking, which taper to a point from a width of 1.5 cm. Furthermore, the Dutch word *spijker* literally means “nail.” Therefore, the wooden pegs used to plug up the nail holes of the temporary cleats, after their removal, should preferably be called “nail plugs” or “nail pegs,” not “spike plugs.” Lemée, *Renaissance Shipwrecks from Christianshavn*, 119–20; and McCarthy, *Ships’ Fastenings*, 176–77.

35. Examples of hull planks of the inner layer of planking that show these nail plugs very clearly are BAT 6375 (loose find); BAT 6068 (loose find, not on plan); BAT 6068, strake 3; and BAT 6390, strake 4.

36. Lemée, *Renaissance Shipwrecks from Christianshavn*, 204, 207 (fig. 4.3.22), 242; and Phaneuf, “Angra C,” 64.

37. The thickness has not been remeasured, as this part of the timber is not accessible because it is on display in the museum.

38. Green, *Loss of the Verenigde Oostindische Compagnie Retourschip Batavia*, 27, 46–49, 46.

39. Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 90.

40. Ibid.

41. Hoving, *Nicolaes Witsens scheeps-bouw-konst open gestelt*, 210.

42. Coolhaas, *Generale missiven van gouverneurs-generaal en raden aan Heren XVII*, 1:478–79.

43. It may also be correct to call it “felt,” a term that does comply with the definition in the *Oxford English Dictionary*. In the latter the following definitions are given for the word *felt*: “1. Skin, felt, or hide of a beast; 2. to mat or press together, or a thickly matted mass of hair or other fibrous substance.” It can be argued that the term is not commonly used until the eighteenth century when it occurs in nautical jargon to refer specifically to a compressed layer of hair applied underneath copper sheathing. Christian Lemée refers to this layer of animal hair as “matting,” which suggests a weave. It is, therefore, not correct to refer to the layer of hair between hull planking and sheathing as matting.

Falconer, *Falconer’s Marine Dictionary* (1780), 261 (sheathing); Lemée, *Renaissance Shipwrecks from Christianshavn*, 203; Witsen, *Architectura navalis et reginem nauticum*, 334; Ronnberg, “Coppering of 19th Century American Merchant Sailing Ships,” 137; Oppenheim, “Royal and Merchant Navy under Elizabeth,” 483; Royal Society of London, “An Extract of a Letter,” 190–91; and Ure, *Dictionary of Arts, Manufactures, and Mines*, 454–55.

44. Baker and Green, “Recording Techniques Used during the Excavation of the *Batavia*,” 148. In 1983, two hair samples from *Batavia*’s timbers BAT 4123 and BAT 6249 were identified as a mixture of predominantly horsehair and some goat hair. The identification was based on a microscopic examination of distinguishing features, such as the shape of the medulla, which is “commonly interrupted in the cattle hair and often with [a] ‘serrated edge’ in the horsehair” and “the absence of the large, spindle-shaped aggregations of pigment granules found scattered throughout the cortex of a cattle hair.” Horsehair is, however, not easily identified with certainty, as is exemplified by an FBI report published in 2004, which states that their specialists have difficulties with the determination of horsehair. In order to distinguish between the hair of cattle and horses, it is usually necessary for the root to be present. It is, therefore, essential to be critical of a positive identification that differentiates between them, especially as the condition of the hair from the *Batavia* planking is expected to be relatively poor. Deedrick and Koch, “Microscopy of Hair Part II”; and Mills, unpublished reports, 8 June 1983, 13 June 1983.

45. Brunner and Triggs, *Hair ID*.

46. Henk van Haaster, letter to author, 7 March 2007.

47. Ibid., 29 March 2007.

48. Toby Jones, letter to author, 13 March 2008.

49. Ryder, “Animal Hair in Medieval Ship Caulking,” 61, 61–62.

50. Cappers et al., “Analysis of Caulking Material,” 577, 585.

51. Hall, "A Seventeenth-Century Northern European Merchant Shipwreck," 70; Lightley, "An 18th Century Dutch East Indiaman," 309; and Rittenhouse, "Mitochondrial DNA Control Region Sequences," 11.
- A hair sample of matting found on pine sheathing of the VOC ship *Zeewijk* was analyzed as possibly cattle hair or horsehair by Henk van Haaster, BIAx Consult. Henk van Haaster, letter to author, 7 March 2007.
52. Baker and Green, "Recording Techniques Used during the Excavation of the *Batavia*," 148; Den Braven et al., *De Buytensorgh*, 48, 62, 159, 161; L'Hour, Long, and Rieth, *Le Mauritius*, 215; and Larn, "Wreck of the Dutch East Indiaman *Campan*," 15.
53. Witsen, *Architectura navalis et reginem nauticum*, 334; and Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 91.
54. Meijer, *Leer in beeld*, 26.
55. Matthee, *Politics of Trade in Safavid Iran*, 164; and Floor, "Dutch Relations with the Persian Gulf," 252.
56. Gawronski, *De equipage van de Hollandia en de Amsterdam*, 276, 278.
57. Lemée, *Renaissance Shipwrecks from Christianshavn*, 203; and Marsden, "Wreck of the Dutch East Indiaman *Amsterdam*," 82.
58. Van Beylen, *Schepen van de Nederlanden*, 42; and Loewen, "Resinous Paying Materials," 240. For discussion of the differences between tar and pitch, see Loewen, "Resinous Paying Materials," 238–52; Beck et al., "Ancient Pine Tar Technology," 179–84; and Kühn, "Detection and Identification of Waxes," 71–81.
59. Pine tar components were confirmed in a recent preliminary analysis of a *Batavia* hair sample from BAT 6249 by Henk van Keulen of the Instituut Collectie Nederland. The sample was extracted in a solution of 2.5% tetra methyl ammonium hydroxide in methanol. Henk van Keulen, report to author, 12 August 2008.
60. Hall, "A Seventeenth-Century Northern European Merchant Shipwreck," 70–74; and Rittenhouse, "Mitochondrial DNA Control Region Sequences," 8.
61. Lemée, *Renaissance Shipwrecks from Christianshavn*, 203.
62. Ghisalberti and Godfrey, "Application of Nuclear Magnetic Resonance Spectroscopy," 1–8, 3. Additional scientifically based studies on paying materials used on VOC shipwrecks *Batavia*, *Vergulde Draak*, *Zeewijk*, and *Zuiddorp* are currently in progress (in cooperation with Emil Ghisalberti and Ian Godfrey).
63. Ian D. MacLeod, letter to author, 29 December 2009.
64. Lemée, *Renaissance Shipwrecks from Christianshavn*, 205.
65. Green, "Planking-First Construction of the VOC Ship *Batavia*," 70.
66. Green, *Loss of the Verenigde Oostindische Compagnie Retourschip Batavia*, 12, and "The VOC Ship *Batavia* Wrecked

- in 1629," 52, 57–63; and Ingelman-Sundberg, "The VOC Ship *Batavia* 1629," 47.
67. Lemée, *Renaissance Shipwrecks from Christianshavn*, 213–14.
68. Van IJk referred to the use of copper sheets placed around the sternpost and stem to provide extra protection. Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 289.
69. Baker and Green, "Recording Techniques Used during the Excavation of the *Batavia*," figs. 6, 8, 9; and Green, *Loss of the Verenigde Oostindische Compagnie Retourschip Batavia*, 19.
70. Witsen, *Architectura navalis et reginem nauticum*, 111.
71. Israel, *Dutch Primacy in World Trade*, 96.
72. Daalder et al., *Goud uit graan*, 13.
73. Samples were taken by Glenn Grieco and the author, using new titanium drill bits (<F>1/16</F> in) to get uncorroded copper from the center of the tack heads. A new bit was used for each nail to avoid sample contamination, and the shavings of the first few millimeters were discarded to avoid interference of corrosion products with the test results.
74. This reference value is specified in Baker et al., "Pb Isotopic Analysis of Standards and Samples," 275–303.
75. Sundblad, "Genetic Reinterpretation of the Falun and Åmmeberg Ore Types," 170.
76. Kjell Billström, reports to author, 16 October and 6 December 2007.
77. Israel, *Dutch Primacy in World Trade*, 177, 180, 250, 255, 256, 392, 407; Pare, *Metals Make the World Go Round*; and Shimada, *The Intra-Asian Trade in Japanese Copper*, 67–84.
78. Israel, *Dutch Primacy in World Trade*, 172; and Shimada, *The Intra-Asian Trade in Japanese Copper*, summary.
79. Heeres, *Dagh-register gehouden int Casteel Batavia*, 216.
80. Kjell Billström, report to author, 6 December 2007.
81. Ibid., 16 October and 6 December 2007.
82. Israel, *Dutch Primacy in World Trade*, 90.
83. Steffy, *Wooden Ship Building*, 139, 295.
84. Green, *Loss of the Verenigde Oostindische Compagnie Retourschip Batavia*, 27, 46–49, 47.
85. Fred Hocker, letter to author, 15 April 2008.
86. McCarthy, *Ships' Fastenings*, 101, 174–76.
87. Simon Jellema, letter to author, 4 April 2008.
88. Janse, "Bouwbedrijf en houtgebruik in het verleden," 43.
89. During the *Batavia* reconstruction in Lelystad, gas burners were used to heat and bend prewetted planks and wales into shape. In a shipyard sketch by Reinier Nooms, a man uses a swagger to wet a plank while it is bent over an open fire; next to him is a bucket with water (see fig. 4-85). During the reconstruction of *Duifje* in Fremantle, builders used traditional methods and bent the planks by applying intense heat over an open wood fire rather than gas burners. Bill Leonard, letter to author, 24 De-

cember 2009. See also Burningham and de Jong, “The *Duyfken* Project,” 291; Parthesius, “Het huiddicht en van de wegering in het gemeen,” 16–18; and Verbiest, “*Batavia* journaal.”

90. Lemée, *Renaissance Shipwrecks from Christianshavn*, 243.

91. Bill Leonard, letter to author, 24 December 2009.

92. The presence of tyloses observed in the xylem vessels of the oak wood was also thought to show that no burning was involved. Tyloses are rather fragile structures that are expected to perish when subjected to high temperatures, as in the process of plank bending. However, a recent study has shown the presence of these structures in archaeological oak heartwood charcoal. Marguerie and Hunot, “Charcoal Analysis and Dendrology,” 1419–20.

CHAPTER 5

1. Bass et al., *Serçe Limani*, 73–238; and Steffy, *Wooden Ship Building*, 79–91.

2. American Numismatic Rarities, *The Classics Sale*, 281–82; Sotheby, *Catalogue of Treasure Recovered off the Shetland Isles*; and Christie’s Amsterdam, *Important Gold, Silver, Jewellery and Artifacts Recovered*.

3. Toebosch, “‘T Vliegend Hert,” 130, 130–31.

4. Ibid., 146, 138, 145.

5. Van Duivenvoorde, “Dutch Ministry of Finance Violates Agreement,” 15–16.

6. Sténuit, “De Witte Leeuw,” 165–69.

7. Van der Pijl-Ketel, *The Ceramic Load of the Witte Leeuw*, 23; and Sténuit, “De Witte Leeuw,” 173–74.

8. Sténuit, “De Witte Leeuw,” 173–74.

9. Van der Pijl-Ketel, *The Ceramic Load of the Witte Leeuw*, 23.

10. Ibid., 23–26; Sténuit, “De Witte Leeuw,” 170–77.

11. Sténuit, “The Sunken Treasure of St. Helena,” 568–69.

12. Hoving and Emke, *Het schip van Willem Barents*, 33–34, 16.

13. Green, “The VOC Ship *Batavia* Wrecked in 1629,” 43–63; Green, “Planking-First Construction of the VOC Ship *Batavia*,” 70–71; L’Hour, Long, and Rieth, *Le Mauritius*, and “The Wreck of an ‘Experimental’ Ship,” 63–73; Maarleveld, *Archaeological Heritage Management in Dutch Waters*, 95–96, 125–26; and Vos, “De replica van een VOC-retourschip te Lelystad,” 48–55.

14. Lemée, *Renaissance Shipwrecks from Christianshavn*, 23, 29.

15. VOC ship *Kampen*, which sank in 1627 on the Needles rocks (Isle of Wight, UK) is, for example, not included because its poorly preserved hull remains have not been subject to scholarly scrutiny. It has been published that no significant hull remains were found and include only a few fragments and some pine sheathing. Larn, “Wreck of the Dutch East Indiaman *Kampen*,” 15.

16. Hoving and Emke, *Het schip van Willem Barents*, 33.

17. Ibid., 15.

18. Ibid., 52.

19. Ibid., 52, 34.

20. Maarleveld, “Schiffsarchäologie im Wattenmeer,” 103–7, and “Het schip Scheurrak SO1,” 573–77; and Manders, “Mysteries of a Baltic Trader,” 320.

21. Maarleveld, “Archaeology and Early Modern Merchant Ships,” 164; Manders, “Mysteries of a Baltic Trader,” 326, and “The BZN 10-Wreck,” 99–100.

22. Manders, “Mysteries of a Baltic Trader,” 326–27.

23. Thijs J. van Maarleveld, letter to author, 14 May 2003.

24. Van der Heide, “Reconstructie van een bijzondere Italiaanse trompet van de vindplaats Scheurrak SO1,” 107; Manders, “Mysteries of a Baltic Trader,” 323–24, and “Raadsels rond een gezonken oostzeevaarder,” 75–77.

25. Maarleveld, “Het schip Scheurrak SO1,” 574; and Vos, “De replica van een VOC-retourschip te Lelystad,” 51.

26. Maarleveld, “Het schip Scheurrak SO1,” 574, and “Archaeology and Early Modern Merchant Ships,” 164; and Vos, “De replica van een VOC-retourschip te Lelystad,” 51.

27. Maarleveld, “Het schip Scheurrak SO1,” 573.

28. Maarleveld, “Archaeology and Early Modern Merchant Ships,” 164–65, 164.

29. Maarleveld, “Double Dutch Solutions in Flush-Planked Shipbuilding,” 159.

30. Thijs J. van Maarleveld, letter to author, 3 December 2007; and Van IJk, *De Nederlandsche scheeps-bouw-konst open gesteld*, 81.

31. During the ship’s excavation, only the fore- and aftermost parts of the keel were raised, and the keel timber in between was left in situ on the seabed. It is not known how many pieces the keel timber comprises. Thijs J. van Maarleveld, letter to author, 14 May 2003; and Maarleveld, “Archaeology and Early Modern Merchant Ships,” 164.

32. Lemée, *Renaissance Shipwrecks from Christianshavn*, 15–16, 23–24, 196.

33. Ibid., 23, 196, 23, 217–18.

34. Ibid., 23, 298.

35. Ibid., 210–12.

36. Ibid., 204–10.

37. Ibid., 203; and Markham, *The Hawkins’ Voyages*, 203.

38. Lemée, *Renaissance Shipwrecks from Christianshavn*, 205–6, 208.

39. Ibid., 217–18, 227–28, 217–18.

40. Ibid., 307–8.

41. Lemée, *Renaissance Shipwrecks from Christianshavn*, 206.

42. Ibid., 213, 23, 202.

43. Phaneuf, “Angra C,” II, 2–3, 120–23; and Garcia and Monteiro, “Excavation and Dismantling of Angra D,” 431–47. A

preliminary study of Angra C was published in Garcia and Monteiro. Data of the Angra C shipwreck from this particular article have, however, been omitted in this study, as they are from the 1998 field campaign. They predate Erik Phaneuf's more scholarly study made in 2000.

44. Phaneuf, "Angra C," 54–55, 7, 54–58.
45. Erik Phaneuf, letter to author, 18 August 2007.
46. Phaneuf, "Angra C," 57, 139 (fig. 15), 56–57, 148 (fig. 37).
47. Ibid., 59–62, 63, 85–86.
48. Ibid., 68–69, 67–69, 68, 58.
49. Ibid., 73–74.
50. Ibid., 70–71, 71–72.
51. Ibid., 69.
52. Ibid., 83–85, 84–85, 83.
53. NA, Verenigde Oostindische Compagnie, item no. 99 (Kopie-resoluties van de Heren XVII, 1602–7), folio 161; Bruijn, Gaastra, and Schöffner, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, vol. 2, nos. 0096.2, 0097.1, 0098.2, 0099.1, 0100.2, 0101.1, 0102.1, 0103.1, 0104.1; Matelief de Jonge, "Historische verhael vande treffelijcke reyse," 1.
54. On 3 April 1606, Matelief informed his men of the undisclosed VOC instructions to siege Malacca. Initially, this caused serious tension with the crew because they had enlisted in VOC service as sailors, not soldiers. Matelief de Jonge, "Historische verhael vande treffelijcke reyse," 6.
55. Bruijn, Gaastra, and Schöffner, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, vol. 2, nos. 0105.2, 0106.1; and Matelief de Jonge, "Historische verhael vande treffelijcke reyse," 22. In a preliminary publication on the *Nassau* shipwreck, this event is dated erroneously to 14 June 1606. See Bound, Hin, and Pickford, "The Dutch East Indiaman *Nassau*," 86.
56. Boxer, *Affair of the "Madre de Deus,"* 23.
57. Matelief de Jonge, *An Historicall and True Discourse*, 14; Matelief de Jonge, "Historische verhael vande treffelijcke reyse," 39–40.
58. Matelief de Jonge, "Historische verhael vande treffelijcke reyse," 39–40.
59. Boxer, *Affair of the "Madre de Deus,"* 28–29; Matelief de Jonge, "Historische verhael vande treffelijcke reyse," 6–51; and Matelief de Jonge, *An Historicall and True Discourse*, 22–23.
60. Israel, *The Dutch Republic*, 536.
61. Matelief de Jonge, "Historische verhael vande treffelijcke reyse," 167–70. Matelief mentions the burning of three Dutch ships (page 14), but apart from *Kleine Zon* and *Grote Zon*, all other ships from his fleet returned to the Netherlands, so it is not certain what the third ship would have been. *Grote Zon* was left behind in 1610 in Banda, incapable of sailing. See De Booy, *De derde reis van de V.O.C. naar Oost-Indië*, 2:233; Bruijn, Gaastra, and Schöffner, *Dutch-Asiatic Shipping in the 17th and 18th Centu-*

ries, 2:21, and vol. 3, no. 5083.1; and Parthesius, "Dutch Ships in Tropical Waters," 175.

62. NA, Verenigde Oostindische Compagnie, item no. 99 (Kopie-resoluties van de Heren XVII, 1602–7), folio 170, 1604.
63. De Booy, *De derde reis van de V.O.C. naar Oost-Indië*, 2:191, 204, 216, 220.
64. Ibid., 220; and Parthesius, "Dutch Ships in Tropical Waters," 175.
65. Bruijn, Gaastra, and Schöffner, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, vol. 2, no. 0074.1, and vol. 3, no. 5057.1; and Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 15.
66. Bruijn, Gaastra, and Schöffner, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, vol. 2, no. 0037.1, and vol. 3, no. 5020.1; and Van Caerden, "Kort verhael ofte Journael van de Reyse gedaen naer de Oost Indien met 4 schepen," 1.
67. Bruijn, Gaastra, and Schöffner, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, 2:8, nos. 0035.1, 0036.1, 0037.1, 0038.1.
68. Rietbergen, *De eerste landvoogd Pieter Both*, 1:160; Van Foreest and De Booy, *De vierde schipvaart der Nederlanders naar Oost-Indië*, 1:127.
69. Boxer, *Affair of the "Madre de Deus,"* 24; and Matelief de Jonge, *An Historicall and True Discourse*, 8. According to Mensun Bound, Commelin mentions specifically that *Nassau* exploded at the stern. To date, I have not been able to find this reference in the journals kept by Matelief's fleet in Commelin's publication. Bound, Soo Hin, and Pickford, "The Dutch East Indiaman *Nassau*," 87.
70. For information on *boevenet*, see appendix A, note 4.
71. Matelief de Jonge, "Historische verhael vande treffelijcke reyse," 186; and L'Hermite de Jonge, *Breeder verhael ende klare beschrijvinge van tghene den admiraal Cornelis Matelief de Jonge*, 339.
72. Markham, *The Hawkins' Voyages*, 287–88.
73. Matelief de Jonge, "Historische verhael vande treffelijcke reyse," 186. The letters of L'Hermite de Jonge to his father can be found on pages 140–87.
74. Bound, Soo Hin, and Pickford, "The Dutch East Indiaman *Nassau*," 97.
75. NA, Verenigde Oostindische Compagnie, item no. 99 (Kopie-resoluties van de Heren XVII, 1602–7), folio 6, 14 April 1602, and folio 8; Bruijn, Gaastra, and Schöffner, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, vol. 2, no. 0073.1, and vol. 3, no. 5052.1.
76. NA, Verenigde Oostindische Compagnie, item no. 99 (Kopie-resoluties van de Heren XVII, 1602–7), folio 161, 14 April 1602; Matelief de Jonge, "Historische verhael vande treffelijcke reyse," 1; and L'Hour, Long, and Rieth, "The Wreck of an 'Experimental' Ship," 64.

77. NA, Verenigde Oostindische Compagnie, item no. 99 (Kopie-resoluties van de Heren XVII, 1602–7), folio 146, September–December 1604.
78. The VOC would not have bought a ship partly built and/or assembled from inferior materials, as the risk of losing valuable cargo would have been too high.
79. L'Hour, Long, and Rieth, *Le Mauritius*, 228, and “The Wreck of an ‘Experimental’ Ship,” 64.
80. Bruijn, Gaastra, and Schöffer, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, vol. 2, nos. 0004.1, 0014.2, 0034.3; and vol. 3, nos. 5003.1, 5006.2, 5018.3.
81. Bruijn, Gaastra, and Schöffer, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, vol. 3, no. 5077.2.
82. L'Hour, Long, and Rieth, *Le Mauritius*, 8.
83. *Ibid.*, 197–99, 203; and L'Hour, Long, and Rieth, “The Wreck of an ‘Experimental’ Ship,” 64–65.
84. L'Hour, Long, and Rieth, *Le Mauritius*, 205, and “The Wreck of an ‘Experimental’ Ship,” 65.
85. L'Hour, Long, and Rieth, *Le Mauritius*, 215–16, and “The Wreck of an ‘Experimental’ Ship,” 65.
86. L'Hour, Long, and Rieth, *Le Mauritius*, 197–201.
87. *Ibid.*, 215–16; and L'Hour, Long, and Rieth, “The Wreck of an ‘Experimental’ Ship,” 65.
88. Maarleveld, *Archaeological Heritage Management in Dutch Waters*, 94 (fig. 29), 119, 130–31, and “Double Dutch Solutions in Flush-Planked Shipbuilding,” 156–61; and Maarleveld, Goudswaard, and Oosting, “New Data on Early Modern Dutch-Flush Shipbuilding,” 15 (fig. 4).
89. Witsen, *Architectura navalis et regimem nauticum*, 169.
90. Green, “The *Vergulde Draeck* Excavation 1981 and 1983,” 1–8, and “*Vergulde Draeck* Excavation 1981,” 46–47.
91. Green, *Loss of the Verenigde Oostindische Compagnie Jacht Vergulde Draak*, 1:71, 23.
92. NA, Verenigde Oostindische Compagnie, item no. 363 (Adviezen van rechtsgeleerden uitgebracht aan de bewindhebbers van de VOC 1622–1723), 24 January 1653.
93. Green, *Loss of the Verenigde Oostindische Compagnie Jacht Vergulde Draak*, 1:81, 90.
94. *Ibid.*, 249–50; and Green, “Wreck of the Dutch East Indiaman the *Vergulde Draeck*,” 287.
95. Green, “Wreck of the Dutch East Indiaman the *Vergulde Draeck*,” 287.
96. More specifically in grid squares 17.5 S/20 E, 21 S/18 E, 21 S/19 E, 22 S/16 E, 22 S/18 E, 22.5 S/21 E, 23 S/19 E, 24 S/19 E, 27 S/20 E, 25 S/20 E, and 27.5 S/18.5 E.
97. One lot of timbers accessioned into the Western Australian Museum’s collection can contain more than one timber of the same descriptor, so some lots represent several timbers.
98. Identification up to genus level by Caroline Vermeeren of BIAAX Consult, the Netherlands, and up to species level by Nili Liphshitz of the Botanical Laboratories of the Institute of Archaeology, Tel Aviv University, Israel. Liphshitz, “Dendro-archaeological Investigations”; and Van Rijn, “Analysis of Ten Wood Samples.”
99. Hull fragments specifically described and discussed include their museum registration number, which begins with the shipwreck’s designation, GT, and a four-digit catalog number.
100. GT 6123 B, GT 6135, GT 6172 E, and GT 6173.
101. GT 6172 E and GT 6173.
102. Adams, van Holk, and Maarleveld, *Dredgers and Archaeology*, 114; and Lightley, “An 18th Century Dutch East Indiaman,” 310–11.
103. Den Braven et al., *De Buytensorgh*, 27.
104. GT 1386 C, GT 1386 P, GT 6008, GT 6129, GT 6168, and GT 6178.
105. GT 98 A, GT 1387 C, GT 1404 A, GT 1405 B, GT 6020, GT 6123 D, GT 6142 B, and GT 6174.
106. Simon Jellema, letter to author, 22 May 2007.
107. Identification made by Henk van Haaster, BIAAX Consult, the Netherlands.
108. Henk van Haaster, letter to author, 21 November 2007.
109. Green, *Loss of the Verenigde Oostindische Compagnie Jacht Vergulde Draak*, 1:206–7. At the bottom of page 207 is reference to “(GT 92 and GT 921),” which should have been “GT 91 and GT 92.”
110. These sheets have previously been published as one layer of copper sheathing with two layers of lead lining (under registration number GT 1442, which is now GT 1442 and GT 3169), but during its conservation this turned out to be incorrect. Green, *Loss of the Verenigde Oostindische Compagnie Jacht Vergulde Draak*, 1:207.
111. The samples from *Vergulde Draak* sternpost sheathing were analyzed at the CSIRO laboratories, Perth, Western Australia, using a SEM with a SUTW-Sapphire detector. This is a semiquantitative method of conducting chemical analysis by spot testing. The areas analyzed on each sample vary in size between 250 and 300 μm . As this is a localized testing method of analysis, it is not necessarily representative for the composition of the entire sample. Therefore, preferably two or more small areas per sample were tested.
112. The following SEM settings were used during data acquisition: Kilovoltage: kV 30; EDAX ZAF Quantification; Element Normalized; SEC table: default, standardless; resolution: 160.70; tilt: 0.00; tc: 2.5. The time per sample analysis was set to about 60 seconds for each test.
113. Parthesius, “Het wrak van VOC-schip *Avondster* in de haven van Galle (Sri Lanka),” 65.
114. *Ibid.*, 64–65; Bruijn, Gaastra, and Schöffer, *Dutch-Asiatic*

Shipping in the 17th and 18th Centuries, vol. 2, no. 0823.1; and vol. 3, nos. 5409.1, 5448.2.

114. Parthesius, “Het wrak van VOC-schip *Avondster* in de haven van Galle (Sri Lanka),” 64.

115. Sainsbury, *Calendar of the Court Minutes*, xxi, 205, 208, 209, 217.

116. Bruijn, Gaastra, and Schöffner, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, vol. 3, no. 5409.1; Parthesius, “Het wrak van VOC-schip *Avondster* in de haven van Galle (Sri Lanka),” 64; NA, Verenigde Oostindische Compagnie, item no. 1196 (Overgekomen brieven en papieren uit Indië aan de Heren XVII en de kamer Amsterdam), folio 313, 1654, and item no. 1202 (Overgekomen brieven en papieren uit Indië aan de Heren XVII en de kamer Amsterdam), folio 241, 1655.

117. Foster, *English Factories in India*, 7:26–27, 121–22.

118. Bruijn, Gaastra, and Schöffner, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, vol. 2, no. 0823.1; and vol. 3, nos. 5409.1, 5448.2.

119. The Sri Lankan Mutual Heritage Centre, Central Cultural Fund, Department of Archaeology, Department of National Museums, Post-Graduate Institute of Archaeology, and the University of Kelaniya with the Amsterdam Historical Museum, University of Amsterdam, and the Western Australian Museum.

120. Murray, “Interpretation of the Anglo-Dutch East-Indiaman *Avondster* Ship’s Construction,” 131–53; Parthesius et al., *Sri Lanka Maritime Archaeological Unit Report on the Avondster Project*, 8.

121. *Avondster*’s hull is well preserved, but it is by no means “better preserved [hull remains] than other VOC shipwrecks,” according to Murray in the shipwreck’s final publication. First, the precise extent of the hull will remain unknown until further and more intensive investigation is carried out. Moreover, as explained previously, the archaeological hull remains of other known VOC shipwrecks, such as *Middelburg*, *Nassau*, and *Witte Leeuw*, are also well preserved. Murray, “Interpretation of the Anglo-Dutch East-Indiaman *Avondster* Ship’s Construction,” 153; and Parthesius et al., *Sri Lanka Maritime Archaeological Unit Report on the Avondster Project*, 4.

122. Murray, “Interpretation of the Anglo-Dutch East-Indiaman *Avondster* Ship’s Construction,” 138; and Parthesius et al., *Sri Lanka Maritime Archaeological Unit Report on the Avondster Project*, 4, 18, 39.

123. Murray, “The Interpretation of the Anglo-Dutch East-Indiaman *Avondster* Ship’s Construction,” 138.

124. This identification may not be representative for the ship’s hull planking in general, especially regarding the ship’s old age at the time of sinking and evidence for repairs and mainte-

nance work throughout its life. See *ibid.*, 136, 144; and Parthesius et al., *Sri Lanka Maritime Archaeological Unit Report on the Avondster Project*, 39.

125. Parthesius et al., *Sri Lanka Maritime Archaeological Unit Report on the Avondster Project*, 39.

126. Murray, “Interpretation of the Anglo-Dutch East-Indiaman *Avondster* Ship’s Construction,” 144.

127. Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 90.

128. Murray, “Interpretation of the Anglo-Dutch East-Indiaman *Avondster* Ship’s Construction,” 144, 145.

129. *Ibid.*, 140–42, 143–44, 143–44.

130. *Ibid.*, 140–42; and Batchvarov, “Framing of Seventeenth-Century Men-of-War,” 46, 154, 158–59.

131. Murray, “Interpretation of the Anglo-Dutch East-Indiaman *Avondster* Ship’s Construction,” 146.

132. Maarleveld, *Archaeological Heritage Management in Dutch Waters*, 126.

133. Murray, “Interpretation of the Anglo-Dutch East-Indiaman *Avondster* Ship’s Construction,” 141.

134. Murray states, for example, that hanging knees were used in English and Dutch shipbuilding, whereas lodging knees were characteristic of English shipbuilding. This is incorrect, as demonstrated by the deck lodging knee preserved on the *Batavia*. See *ibid.*, 148.

135. Larn and Larn, *Shipwreck Index of the British Isles*, vol. 1, sec. 3, “Isles of Scilly”; and Sténuit, “Early Relics of the VOC Trade from Shetland,” 221.

136. Larn, “Wrecks round the Scillies,” 31; and Larn and Larn, *Shipwreck Index of the British Isles*, vol. 1, sec. 3, “Isles of Scilly.”

137. Werz, “*Een bedroefd, en beclaaglijck ongeval*.”

138. Bruno E. J. S. Werz, letter to author, 2 August 2005. Original message: “Kan je niet verder helpen met scheepshout. Zowel de *Oosterland* als de *Waddinxveen* zijn bij de ondergang in stukken geslagen en archiefstukken benadrukken dit. Wat er aanspoelde is weggevoerd om te dienen als bouw materiaal of brandhout. Tijdens de opgraving hebben we bijzonder weinig hout gevonden en dat was sterk gefragmenteerd en in de meeste gevallen niet te identificeren. We hebben dit onderwater laten liggen omdat er hier geen faciliteiten zijn om hout te conserveren. Er is niets gevonden dat duidelijk deel uitmaakt van de romp; zelfs geen spoor van de kiel.”

139. Werz, “*Een bedroefd, en beclaaglijck ongeval*,” 70.

140. Muckelroy, *Archeology under Water*, 125; and Price and Muckelroy, “The *Kennemerland* Site,” 195, 214.

141. Muckelroy, *Archeology under Water*, 125.

142. Price and Muckelroy, “The *Kennemerland* Site,” 214.

CHAPTER 6

1. NA, Verenigde Oostindische Compagnie, item no. 307 (Zakenindex op de resoluties van de kamer Amsterdam, 1602–1743), 441, 6 January 1606 and 18 September 1615; Commelin, “Historisch verhael vande reyse gedaen inde Oost-Indien,” 85; Engelbrecht and van Herwerden, *De ontdekkingsreis van Jacob le Maire en Willem Cornelisz*, 157; Parthesius, “De dubbele huid van Oostindievaarders aan het begin,” 26; Parmentier, Davids, and Everaert, *Peper, plancius en porselein*, 120; Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 458–59; Van Linschoten, *Reizen van Jan Huyghen van Linschoten naar het Noorden*, 263; Van Spilbergen, *De reis om de wereld van Joris van Spilbergen*, 1614–1617, 129, 161; and De Booy, *De derde reis van de V.O.C. naar Oost-Indië*, 1:14.
2. Van Beylen, *Schepen van de Nederlanden*, 42–43; Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 454; Diekerhoff, *De oorlogsvloot in de zeventiende eeuw*, 34; Elias, *De vlootbouw in Nederland*, 11; and Vos, “De replica van een VOC-retourschip te Lelystad,” 50.
3. For information on *verdubbeling* or *dubbeling*, see Witsen, *Architectura navalis et reginem nauticum*, 334; and Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 87, 91–92, 289, 292.
4. Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 91, 292.
5. According to Vos, only historical documents of the middle to late seventeenth century are available for the study of the construction of ships with double-hull planking, but in the archives of the VOC and travel journals of the early seventeenth century, numerous references are made to the construction of double-planked ships. Vos, “De replica van een VOC-retourschip te Lelystad,” 52.
6. NA, Verenigde Oostindische Compagnie, item no. 307 (Zakenindex op de resoluties van de kamer Amsterdam, 1602–1743), 441, 6 January 1606; item no. 226 (Resoluties van de ordinaris en extraordinaris vergaderingen van de kamer Amsterdam, 14 June 1604–8 February 1610), 2 January 1606 and 6 January 1606; and item no. 100 (Kopie-resoluties van de Heren XVII, 1608–23), folio 218, November 1613.
7. Witsen, *Architectura navalis et reginem nauticum*, 334; and Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 87, 289, 292.
8. Van Linschoten, *Reizen van Jan Huyghen van Linschoten naar het Noorden*, 263.
9. Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 458–59; and Hoving and Emke, *Het schip van Willem Barents*, 111.
10. The charter states that the hull planking is doubled from the bottom up to the quarterdeck wale with *Oostersche plancken*

(eastern planks), which are oak planks imported from the countries on the *Oostzee*, or Baltic Sea. NA, Verenigde Oostindische Compagnie, item no. 99 RJ (Kopie-resoluties van de Heren XVII, 1602–7), folio 67; and Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 457.

Dutch historic research has demonstrated a clear distinction in Old Dutch between use of the plural noun *planken* (planks) and *delen* (boards). The first refers to oak planks, whereas the latter refers to pine planks. Van IJk, for example, does not use the word *delen* to refer to planking while discussing the use of oak planks, and by the same token he does not mention the word *planken* while discussing pine sheathing. Schillemans mentions that the word *delen*, in all catalogs of the Zaandam timber auctions dating from 1655 to 1811, refers exclusively to pine or fir planks. Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 35–46; and Schillemans, *De houtveilingen van Zaandam in de jaren 1655–1811*, 62.

11. NA, Admiraliteitscolleges, item no. 1360; Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 450; and Parthesius, “De dubbele huid van Oostindievaarders aan het begin,” 26.

12. NA, Verenigde Oostindische Compagnie, item no. 307 (Zakenindex op de resoluties van de kamer Amsterdam, 1602–1743), 441, and item no. 226 (Resoluties van de ordinaris en extraordinaris vergaderingen van de kamer Amsterdam, 14 June 1604–8 February 1610), 14 November 1605, 2 January 1606, and 6 January 1606; and De Booy, *De derde reis van de V.O.C. naar Oost-Indië*, 1:37.

13. Elias, *De vlootbouw in Nederland*, 11. This particular vessel sailed to Brazil in a fleet of five ships under command of Paulus van Caerden in 1603 and returned in 1604–5 (page 12). It is not the *Hollandse Tuin* (360/440 tons) that sailed to Atjeh and Bantam for the VOC Enkhuizen Chamber on 17 June 1602 and returned to Holland on 8 April 1605. Bruijn, Gaastra, and Schöffner, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, vol. 2, no. 0077.1; and vol. 3, no. 5060.1.

14. Engelbrecht and Van Herwerden, *De ontdekkingsreis van Jacob le Maire en Willem Cornelisz*, 16, 157. According to Parthesius, this large horned fish was probably a narwhal. However, narwhals are Arctic whales and only rarely travel south of the Arctic Circle (Northern Hemisphere) into warmer waters. Furthermore, it would be just as rare for a narwhal to collide with a large ship because it is very skittish and afraid of sounds/humans. It may have been a swordfish, which can gain enough speed for such a collision. Kristin Laidre, narwhal expert, letter to author, 28 January 2013. See also Parthesius, “De dubbele huid van Oostindievaarders aan het begin,” 26–27.

15. Engelbrecht and Van Herwerden, *De ontdekkingsreis van Jacob le Maire en Willem Cornelisz*, 16, 157.

16. NA, Verenigde Oostindische Compagnie; Coen, *Bescheiden omtrent zijn bedrijf in Indië*, 1:73, 143, 3:352, 664–67; vol. 7, no. 1, 15–16, 628–29, 649; and vol. 7, no. 2, 985, 1507, 1579; Coolhaas, *Generale missiven van gouverneurs-generaal en raden aan Heren XVII*, 478–79; De Booy, *De derde reis van de V.O.C. naar Oost-Indië*, 1:51, 67, 90, and 2:62, 150–52, 162, 216; and Van Spilbergen, *De reis van Joris van Spilbergen naar Ceylon*, 75, 88.

17. Royal Society of London, “An Extract of a Letter,” 190–91.

18. Coen, *Bescheiden omtrent zijn bedrijf in Indië* (1952), vol. 7, no. 1, 649, 1:581, 3:625. The Dutch East Indiaman *Morgenster* was last doubled in 1618 in Bantam or the islands near Jakarta. Ibid., 1:388.

19. The following references date to, or refer to documents dating between, 1599 and 1634 and are listed as examples only, as there are undoubtedly more references to replanking or resheathing of Dutch East Indiamen in Asia. Specifically regarding replanking from “the keel up,” see Rietbergen, *De eerste landvoogd Pieter Both*, 2:317–19; Coen, *Bescheiden omtrent zijn bedrijf in Indië*, 1:143, 2:109, 4:52, 55, 58, 60, and vol. 7, no. 1, 786.

For general references to replanking, see Coen, *Bescheiden omtrent zijn bedrijf in Indië*, 1:73, 130, 143, 153, 388, 516, 581, 673; 2:2, 29, 106, 109, 138; 3:10, 351–52, 479, 625, 665–67, 702, 707; 4:52, 55, 58, 60, 66; 5:38; vol. 7, no. 1, 15–16, 26, 29, 93, 102, 191–92, 196, 310–11, 368, 447, 530, 552, 562, 621, 628–29, 639, 786, 804; and vol. 7, no. 2, 985, 1507, 1579, 1661; Commelin, “Historisch verhael vande voyagie der Hollanderen met dry schepen gedaen naer de Oost-Indien,” 3–4; Commelin, “t Historiael journael van voyagie ghedaen met drie Schepen,” 50, 57; Commelin, “Historisch verhael vande reyse gedaen inde Oost-Indien,” 85–86; L’Hermite, “Journael van de Nassausche Vloot,” 11–12; Matelief de Jonge, “Historische verhael vande treffelijcke reyse, gedaen naer de Oost-Indien ende China met elf Schepen,” 174; Van Caerden, “Kort verhael ofte Journael van de Reyse gedaen naer de Oost Indien met 4 schepen,” 17; Coolhaas, *Generale missiven van gouverneurs-generaal en raden aan Heren XVII*, 1:197–98, 241–42, 458, 478–79; De Booy, *De derde reis van de V.O.C. naar Oost-Indië*, 1:51, 67, 90, and 2:143–44, 150–52, 191, 204, 220; L’Honoré Naber, “t Leven en bedrijf van vice-admiraal de With, zaliger,” 83, 93; Rietbergen, *De eerste landvoogd Pieter Both*, 2:241, 317–19; Van den Broecke, *Pieter van den Broecke in Azië*, 62; Van Foreest and De Booy, *De vierde schipvaart der Nederlanders naar Oost-Indië*, 1:275, 2:324, 326; Heeres, *Dagh-register gehouden int Casteel Batavia*, 5, 16, 48, 69, 164, 216, 260, 279, 304, 325; Historisch genootschap, “Twaalfde vergadering,” 538, 547; May, *De reis van Jan Cornelisz*, 145; Van Opstall, *De reis van de vloot van Pieter Willemsz Verhoeff naar Azië*, 117, 124–25, 155, 285; Van Spilbergen, *De reis om de wereld van Joris van Spilbergen, 1614–1617*, 129, 161; Voorbeijtel Cannenburg, *De reis om de wereld van de Nassausche vloot*, 20–22; and W. Unger, *De Oudste Reizen van de Zeeuwen naar Oost-Indië*, 208–9.

20. De Booy, *De derde reis van de V.O.C. naar Oost-Indië*, 1:14, 67, 90. A similar situation is known from June 1599, when the crew of three ships from the fleet under Commander Steven van de Hagen ran into a severely leaking and worm-riddled yacht along the coast of Ethiopia. This yacht, coming from Amsterdam and destined to Benin, was “undoubled” so was without pine sheathing. Commelin, “Historisch verhael vande voyagie der Hollanderen met dry schepen gedaen naer de Oost-Indien,” 3–4.

21. De Booy, *De derde reis van de V.O.C. naar Oost-Indië*, 1:81.

22. Markham, *The Hawkins’ Voyages*, 202.

23. Coolhaas, *Generale missiven van gouverneurs-generaal en raden aan Heren XVII*, 1:478–79.

24. Vos, “De replica van een VOC-retourschip te Lelystad,” 52.

25. Hocker, “Bottom-Based Shipbuilding in Northwestern Europe,” 83; and Parthesius, “De dubbele huid van Oostindievaarders aan het begin,” 29.

26. Witsen, *Architectura navalis et reginem nauticum*, 112, 133; and Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 68, 147–48, 152.

27. Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 147–48.

28. Witsen, *Architectura navalis et reginem nauticum*, 133.

29. For this calculation a wood density of 0.62 tons/m³ is used, which corresponds to the density of both *Quercus petraea* and *Q. robur*. These two oak species were used in Dutch shipbuilding because of their strength and durability. Porsius, “Eiken en grenen,” 57–64; and Hoadley, *Identifying Wood*, 51.

30. Parthesius, “De dubbele huid van Oostindievaarders aan het begin,” 29.

31. Witsen, *Architectura navalis et reginem nauticum*, 112, 133; and Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 68, 147–48, 152.

32. Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 68, 153–54.

33. Bound, Soo Hin, and Pickford, “The Dutch East Indiaman *Nassau*,” 97.

34. Den Braven et al., *De Buytensorgh*, 48; and Lightley, “An 18th Century Dutch East Indiaman,” 309.

35. Witsen, *Architectura navalis et reginem nauticum*, 178.

36. Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 87.

37. Van Spilbergen, *De reis om de wereld van Joris van Spilbergen, 1614–1617*, 160–61; and NA, Admiraliteitscolleges, item no. 1360 (Resoluties, 16 February 1614, 26 February 1614, 2–3 April 1614, 15 April 1614, 1 July 1614, and 4 July 1614).

38. Van Spilbergen, *De reis om de wereld van Joris van Spilbergen, 1614–1617*, 160–61.

39. The cost for the doubling and outfitting both ships was 48,000 guilders, which includes the use of oak planks from

- Hamburg. Ibid.; and NA, Admiraliteitscolleges, item no. 1360 (Resoluties, 16 February 1614, 26 February 1614, 2–3 April 1614, 15 April 1614, 1 July 1614, and 4 July 1614).
40. Steffy, *Wooden Ship Building*, 62–65, 62.
 41. Anderson, “The Burlesdon Ship,” 159–60; and Clarke et al., “Recent Work on the R. Hamble Wreck,” 26.
 42. Friel, *The Good Ship*, 34–35, 67, and “Henry V’s *Grace Dieu*,” 3–19.
 43. Anderson, “The Burlesdon Ship,” 160; and Clarke et al., “Recent Work on the R. Hamble Wreck,” 28.
 44. Anderson, “The Burlesdon Ship,” 160; and Clarke et al., “Recent Work on the R. Hamble Wreck,” 27–28.
 45. Anderson, “The Burlesdon Ship,” 160; and Clarke et al., “Recent Work on the R. Hamble Wreck,” 30–31.
 46. Friel, “Henry V’s *Grace Dieu*,” 4–5.
 47. Friel, *The Good Ship*, 71.
 48. Lemée, *Renaissance Shipwrecks from Christianshavn*, 255–56, 234, 241, 242–43, 253–54.
 49. Wegener Sleswyk, *De Gouden Eeuw van het fluitschip*, 43.
 50. Hocker, “Bottom-Based Shipbuilding in Northwestern Europe,” 84.
 51. Parthesius, “Het wrak van VOC-schip *Avondster* in de haven van Galle (Sri Lanka),” 64.
 52. Hocker, “Bottom-Based Shipbuilding in Northwestern Europe,” 84.
 53. Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 363.
 54. Hoving and Emke, *Het schip van Willem Barents*, 52.
 55. L’Hour, Long, and Rieth, *Le Mauritius*, 214, and “The Wreck of an ‘Experimental’ Ship,” 65.
 56. L’Hour, Long, and Rieth, *Le Mauritius*, 214, and “The Wreck of an ‘Experimental’ Ship,” 65.
 57. Witsen mentions that only the bow of whaling ships was double-planked. Witsen, *Architectura navalis et reginem nauticum*, 178.
 58. Vos, “De replica van een VOC-retourschip te Lelystad,” 54.
 59. NA, Verenigde Oostindische Compagnie, item no. 307 (Zakenindex op de resoluties van de kamer Amsterdam, 1602–1743), 441, 19 August 1603; and item no. 225 (Resoluties van de ordinari en extraordinari vergaderingen van de kamer Amsterdam, 12 August 1602–3 May 1604), 19 August 1603.
 60. Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 458–59; Hoving and Cor Emke, *Het schip van Willem Barents*, 111; and Parthesius, “De dubbele huid van Oostindievaarders aan het begin,” 26.
 61. NA, Verenigde Oostindische Compagnie, item no. 14336 (Rekening van de equipage der schepen de *Amsterdam*—groot 350 lasten—en de *Zon* 1604—groot 120 lasten), folio 4 (Verscheiden materialen tot timmeren ende verdubbelen vande schepen *Amsterdam* ende de *Sonne*) [two pages with a list of materials and equipment], line 3.
 62. Ibid., item no. 307 (Zakenindex op de resoluties van de kamer Amsterdam, 1602–1743), 441, 6 January 1606; and item no. 226 (Resoluties van de ordinari en extraordinari vergaderingen van de kamer Amsterdam, 14 June 1604–8 February 1610), 2 January 1606 and 6 January 1606.
 63. Markham, *The Hawkins’ Voyages*, 202.
 64. Witsen provides a cost of 93,685 guilders for a ship 165 ft long, roughly the size of the *Amsterdam*. Witsen, *Architectura navalis et reginem nauticum*, 176–77; and Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 287–99.
 65. Markham, *The Hawkins’ Voyages*, 202–4; Pyrard, *The Voyage of François Pyrard of Laval to the East Indies*, 1:66, and vol. 2, no. 1, 183; Salville, “3. The Management of the Royal Dockyards,” 125, 129–30; and Temple and Anstey, *The Life of the Icelander Jón Ólafsson*, 61.
 66. IJzerman, *De reis om de wereld door Olivier van Noort*, 99.
 67. Witsen, *Architectura navalis et reginem nauticum*, 334.
 68. Parthesius, “De dubbele huid van Oostindievaarders aan het begin,” 27.
 69. Harland, “Note: Piet Heyn and the Early Use of Copper Sheathing,” 1–2.
 70. Lemmers, *Techniek op schaal*, 65.
 71. American Numismatic Rarities, *The Classics Sale*, 281–82; and Christie’s Amsterdam, *Important Gold, Silver, Jewellery and Artifacts Recovered*.
 72. Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 121.
 73. Den Braven et al., *De Buytensorgh*, 3D-model (Photo-Modeler), 112–15.
 74. Witsen, *Architectura navalis et reginem nauticum*, 334.
 75. Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 733.
 76. Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 51.
 77. Ibid., 91.
 78. Coen, *Bescheiden omtrent zijn bedrijf in Indië*, 1:73; vol. 7, no. 1, 552, 562, 621; 1:388, 581; 3:625; and vol. 7, no. 1, 649. The Dutch East Indiaman *Morgenster* was doubled in 1618 and again in 1620. The ships *Leiden* and *Haarlem* were sheathed almost four years after they had set sail from Holland. Van Foreest and De Booy, *De vierde schipvaart der Nederlanders naar Oost-Indië*, 2:324–26. The entire fleet of Joris van Spilbergen, which circumnavigated the world from 1614 to 1617, was doubled in Jakarta in 1616, two years after its ships had set sail in the fall of 1614. Van Spilbergen, *De reis om de wereld van Joris van Spilbergen, 1614–1617*, 129.
 79. Coolhaas, *Generale missiven van gouverneurs-generaal en raden aan Heren XVII*, 1:479.

80. Den Braven et al., *De Buytensorgh*, 26–27; Green, “Survey of the VOC Fluit *Risdam*,” 95; Habermehl, *Scheepswrakken in de Waddenzee*, 39; Lightley, “An 18th Century Dutch East Indiaman,” 308–10; McCarthy, “Ship Fastenings,” 9; Muckelroy, *Archeology under Water*, 122–28; Parthesius, “Het wrak van VOC-schip *Avondster* in de haven van Galle (Sri Lanka),” 67; and Price and Muckelroy, “The *Kennemerland* Site,” 195, 214.

81. Den Braven et al., *De Buytensorgh*, 26, 48, 62; Green, “Survey of the VOC Fluit *Risdam*,” 95; Habermehl, *Scheepswrakken in de Waddenzee*, 39; Larn, “Wreck of the Dutch East Indiaman *Campan*,” 15; Lightley, “An 18th Century Dutch East Indiaman,” 308–10; Marsden, “Wreck of the Dutch East Indiaman *Amsterdam*,” 82; Muckelroy, *Archeology under Water*, 122–28; Parthesius, “Het wrak van VOC-schip *Avondster* in de haven van Galle (Sri Lanka),” 67; Petersen, “The Dutch Fluitship *Anna Maria*,” 295; Price and Muckelroy, “The *Kennemerland* Site,” 195, 214.

82. Den Braven et al., *De Buytensorgh*, 57.

83. Lemée, *Renaissance Shipwrecks from Christianshavn*, 203 (fig. 4.3.13), 210.

84. Bruijn, Gaastra, and Schöffner, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, vol. 2, no. 3600.1.

85. *Ibid.*, vol. 3, no. 7553.2; and Den Braven et al., *De Buytensorgh*, 45.

86. Den Braven et al., *De Buytensorgh*, 48, 147–48.

87. Murray, “Interpretation of the Anglo-Dutch East-Indiaman *Avondster* Ship’s Construction,” 144.

88. Van Linschoten, *Reizen van Jan Huyghen van Linschoten naar het Noorden*, 147.

89. Coolhaas, *Generale missiven van gouverneurs-generaal en raden aan Heren XVII*, 1:478–79.

90. “Door ’t eeckenhout can oock de roest sich niet soo verspreyen ende alsoo ’t costelijcker valt als met greene deelen.” *Ibid.*

91. Van Foreest and De Booy, *De vierde schipvaart der Nederlanders naar Oost-Indië*, 1:275; Van Spilbergen, *De reis om de wereld van Joris van Spilbergen, 1614–1617*, 129; and Coen, *Bescheiden omtrent zijn bedrijf in Indië*, 1:143.

92. Hoving and Emke, *Het schip van Willem Barents*, 36; and Van Linschoten, *Reizen van Jan Huyghen van Linschoten naar het Noorden*, 263.

93. Meyrelles do Souto, “Hystorya dos cercos que os Olandezes puzerão,” 465–548, 522.

94. De Booy, *De derde reis van de V.O.C. naar Oost-Indië*, 1:45, 110, and 2:131.

95. Bruijn, Gaastra, and Schöffner, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, vol. 2, nos. 0069.1, 0114.2, and vol. 3, no. 5061.1; and NA, *Verenigde Oostindische Compagnie*, item no. 7343 (Kopie-resoluties van de ordinari en extraordinari vergaderingen van de Heren XVII, Kamer Zeeland, 15 April

1602–4 November 1617), folio 6, 16 April 1602, and folio 186, May 1606.

96. De Booy, *De derde reis van de V.O.C. naar Oost-Indië*, 1:34.

97. Translation from Portuguese by Filipe Vieira de Castro and André Murteira:

Os que foram buscar o despojo da nao perdida notarão a fabrica Ecompostura. Pello que mepareção bem dizer neste lugar qual fosse. Era o vazo de tres forros muyto fortes E de boa madeyra, E entre forro E forro tinha outro de pastos de chumbo para // esfriar a madeira que com a quentura senão corrompesse, E daquilha paraçima duas braças tinha hum forro de pinho de dous dedos degrossura, sobre aqual ya agala gala de certas pelles misturadas com alcatrão E breu para durar mais, E se perservar do bicho.

Todos os paioes forrados de latam mourisco porque os mantimentos senão corrompessem nem humedecessem. Não tinha mesas de guarnição nem sintas, nem enxarcias p.^a fora, E era fechada na popa sem mais uaranda que hum, Beliche em que serecolhia o Capitam. Todo o leme forrado das mesmas laminas de latam para lho nam queimarem nem apodreçer. Era de patana e não dequilha, E desta forma affirmão que sam as mais de suas naos, e’ assy ficam sendo fortissimas, E muito ligeiras menos arriscadas nos baixos demandando menos agua, E mais seguras nas // tormentas. (Meyrelles do Souto, “Hystorya dos cercos que os Olandezes puzerão,” 522)

98. Conversion: 2 *dedos* = 0.0183 m × 2 = 0.0366 m. Filipe Vieira de Castro, letter to author, 30 December 2009.

99. See appendix A, “Ship Construction Charters 1603,” folio 67.

100. Gaastra, *The Dutch East India Company*, 17, 19.

101. Van Caerden, “Kort verhael ofte Journael van de Reyse gedaen naer de Oost Indien met 4 schepen,” 17.

102. Commelin, “Historisch verhael vande voyagie der Hollanderen met dry schepen gedaen naer de Oost-Indien,” 3–4.

103. Van Spilbergen, *De reis van Joris van Spilbergen naar Ceylon*, 88; and Van Caerden, “Kort verhael ofte Journael van de Reyse gedaen naer de Oost Indien met 4 schepen,” 17.

104. Van Foreest and De Booy, *De vierde schipvaart der Nederlanders naar Oost-Indië*, 1:275. According to other documents from this fleet, the ships *Leiden* and *Haarlem* were doubled near Cochin in China. *Ibid.*, 2:324–26.

105. Parmentier, Davids, and Everaert, *Peper, plancius en porselein*, 11–15, 25, 118, 119.

106. *Ibid.*

107. *Ibid.*, 120.

108. *Ibid.*, 121.

109. De Jonge, *De opkomst van het Nederlandsch gezag in Oost-Indië*, 258.

110. Rietbergen, *De eerste landvoogd Pieter Both*, 2:241, 317; Coen, *Bescheiden omtrent zijn bedrijf in Indië*, 1:73, 388, 581, 673; 3:625, 702; vol. 7, no. 1, 15, 93, 102, 368, 530, 621, 639, 649; and vol. 7, no. 2, 985; De Booy, *De derde reis van de V.O.C. naar Oost-Indië*, 1:90, 150–52, 191, 204; Heeres, *Dagh-register gehouden int Casteel Batavia*, 69, 84, 260, 325; Historisch genootschap, “Twaalfde vergadering,” 547; L’Honoré Naber, “’t Leven en bedrijf van vice-admiraal de With, zaliger,” 93; Van Opstall, *De reis van de vloot van Pieter Willemsz Verhoeff naar Azië*, 285.
111. Foster, *Letters Received by the East India Company*, 31–34, 34.
112. Coen, *Bescheiden omtrent zijn bedrijf in Indië* (1919), 1:143, 153; 2:29; and 3:351–52.
113. NA, Verenigde Oostindische Compagnie, item no. 100 (Kopie-resoluties van de Heren XVII, 1608–23), folio 161.
The *Zon* and *Maan* should not be confused with the (*Grote*) *Zon* and (*Grote*) *Maan* (600 tons each) that set sail on 8 August 1614 with Commander Joris van Spilbergen to sail around the world. These two ships arrived in Jakarta on 15 September 1616. Van Spilbergen, *De reis om de wereld van Joris van Spilbergen, 1614–1617*, xlv, 1, 129.
114. NA, Verenigde Oostindische Compagnie, item no. 100 (Kopie-resoluties van de Heren XVII, 1608–23), folio 169, point 13 (14 November 1611).
Ships of this fleet were *Eolus* (320 tons), *Gelderland* (600 tons), *Groene Leeuw* (180 tons), *Maan* (400 tons), *Oranje* (600 tons), *Patana* (340 tons), *Rode Leeuw* (340 tons), *Rotterdam* (800 tons), *Ceylon* (340 tons), *Zon* (400 tons), *Ster* (180 tons), *Zeelandia* (500 tons), and the yacht *Duiffe* (50 tons).
In his travel journal Pieter van den Broecke confirms the presence of *Rotterdam* and *Zon* in Asian waters in 1615. *Rotterdam* was part of a fleet of nine ships under command of General Rijnst that anchored in Banda in April 1615. Two other ships that sailed from Holland in Block’s fleet, *Ster* and *Zeelandia*, were also part of this fleet in Banda. Van den Broecke also saw *Zon* on 1 June 1615 close to Ternate in the company of six other VOC ships. Two others that set sail from Holland in Block’s fleet, *Rode Leeuw* and *Patana*, were also part of this fleet in Ternate. Van den Broecke, *Pieter van den Broecke in Azië*, 63, 67.
115. NA, Verenigde Oostindische Compagnie, item no. 100 (Kopie-resoluties van de Heren XVII, 1608–23), folio 153, point 30.
116. Bonke, “Het eiland Onrust,” 47.
117. Ibid.
118. Coen, *Bescheiden omtrent zijn bedrijf in Indië*, vol. 7, no. 1, 530; and Parmentier, Davids, and Everaert, *Peper, plancius en porselein*, 119.
119. Bonke, “Het eiland Onrust,” 45.
120. Coen, *Bescheiden omtrent zijn bedrijf in Indië*, 2:456.
121. Heeres, *Dagh-register gehouden int Casteel Batavia*, 69; Historisch genootschap, “Twaalfde vergadering,” 547; L’Honoré Naber, “’t Leven en bedrijf van vice-admiraal de With, zaliger,” 93; and Wagenaar, “Het eiland Onrust bij Batavia als onderdeel van het VOC-scheepsbedrijf,” 67–68.
122. L’Honoré Naber, “’t Leven en bedrijf van vice-admiraal de With, zaliger,” 93.
123. Historisch genootschap, “Twaalfde vergadering,” 547.
124. Wagenaar, “Het eiland Onrust bij Batavia als onderdeel van het VOC-scheepsbedrijf,” 67–68.
125. Historisch genootschap, “Twaalfde vergadering,” 547.
126. L’Hermite, “*Tournael van de Nassausche Vloot*,” 11–12; and Voorbeijtel Cannenburg, *De reis om de wereld van de Nassausche vloot*, lxvi–lxvii, 20–23.
127. L’Honoré Naber, “’t Leven en bedrijf van vice-admiraal de With, zaliger,” 81–82; and Voorbeijtel Cannenburg, *De reis om de wereld van de Nassausche vloot*, lxi, 11.
128. Bruijn, Gaastra, and Schöffner, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, 2:50–52; L’Honoré Naber, “’t Leven en bedrijf van vice-admiraal de With, zaliger,” 80–81; and Voorbeijtel Cannenburg, *De reis om de wereld van de Nassausche vloot*, 4–6.
129. In the journal kept by Witte Corneliszoon de With, the admiral ship of the fleet, *Amsterdam*, and vice-admiral, *Delft*, are listed as 166 Amsterdam ft (47 m) long. Bruijn, Gaastra, and Schöffner, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, 2:50–53, nos. 0296.1, 0298.1, 0299.1, 0300.1, 0301.1, 0302.1, 0303.1, 0304.1, 0305.1, 0306.1, 0307.1; L’Honoré Naber, “’t Leven en bedrijf van vice-admiraal de With, zaliger,” 80–81; and Voorbeijtel Cannenburg, *De reis om de wereld van de Nassausche vloot*, 4–6.
130. Voorbeijtel Cannenburg, *De reis om de wereld van de Nassausche vloot*, lx, 9, lxiv, 14, lxiii, 13, lxiv, 14, lxiv.
131. Ibid., lxvii, 20; and L’Honoré Naber, “’t Leven en bedrijf van vice-admiraal de With, zaliger,” 83.
132. Voorbeijtel Cannenburg, *De reis om de wereld van de Nassausche vloot*, lxvii, 20–21, lxvii.
133. Ibid., lxvii, 21–23, lxvii, 22.
134. Ibid., lxvii, 22.
135. L’Honoré Naber, “’t Leven en bedrijf van vice-admiraal de With, zaliger,” 83; and Voorbeijtel Cannenburg, *De reis om de wereld van de Nassausche vloot*, 23.
136. Voorbeijtel Cannenburg, *De reis om de wereld van de Nassausche vloot*, lxvii; and Schillemans, *De houtveilingen van Zaandam in de jaren 1655–1811*, 62.
137. Van Opstall, *De reis van de vloot van Pieter Willemsz Verhoeff naar Azië*, 124–25.
138. Verken, *Molukken-Reise 1607–1612*, 132–33. For currency conversion rates, see Turner, “Money and Exchange Rates in 1632”; and Supple, “Currency and Commerce in the Early Seventeenth Century,” 239–55.

139. Van Opstall, *De reis van de vloot van Pieter Willemsz Verhoeff naar Azië*, 127–43.

140. Keuning, *De tweede schipvaart der Nederlanders naar Oost-Indië*, 2:lviii–lxxviii, and vol. 5, no. 1, 60.

141. Ibid., 2:lxix–lxx.

142. Commelin, “Historisch verhael vande reyse gedaen inde Oost-Indien,” 85, 86.

143. NA, Verenigde Oostindische Compagnie, item no. 99 (Kopie-resoluties van de Heren XVII, 1602–7), folio 145 (September 1604), and item no. 100 (Kopie-resoluties van de Heren XVII, 1608–23), folio 191, point 32 (1612).

144. Ibid., item no. 100 (Kopie-resoluties van de Heren XVII, 1608–23), folio 191, point 32 (1612).

145. Coen, *Bescheiden omtrent zijn bedrijf in Indië*, 5:38.

146. Numerous references to the repair and maintenance of ships in Asia can be found in Coen, *Bescheiden omtrent zijn bedrijf in Indië* (1919–53), 7 vols.

147. Heeres, *Dagh-register gehouden int Casteel Batavia*, 16, 84.

148. Bonke, “Het eiland Onrust,” 48.

149. Historisch genootschap, “Twaalfde vergadering,” 537.

150. Coolhaas, *Generale missiven van gouverneurs-generaal en raden aan Heren XVII*, 1:458.

151. This wood species remains unidentified today. Ibid.

152. Ibid. For information on currency conversion rates, see note 138 in this chapter.

153. Coen, *Bescheiden omtrent zijn bedrijf in Indië* (1919), 143.

154. Historisch genootschap, “Twaalfde vergadering,” 538.

155. Heeres, *Dagh-register gehouden int Casteel Batavia*, 84.

156. Bonke, “Het eiland Onrust,” 48–49; and Wagenaar, “Het eiland Onrust bij Batavia als onderdeel van het VOC,” 69, 78–80.

157. Bonke, “Het eiland Onrust,” 49.

CHAPTER 7

1. Porsius, “Eiken en grenen,” 57–64, 57.

2. NA, Verenigde Oostindische Compagnie, item no. 7142 (Journaal van inkomsten en uitgaven), 13 August 1602–9 May 1608; item no. 7169 (Grootboek van inkomsten en uitgaven), 13 August 1602–May 1608; item nos. 13782–85 (Journalen en grootboeken van de kapitaalrekeningen van de eerste tienjarige rekening van de kamer Zeeland, 1602–7), 3 August 1602–31 October 1607; item nos. 13786–93 (Journalen van de equipage van schepen van de kamer Zeeland, 1614–28), 11 August 1614–30 September 1630; and item no. 14854 (Journaal van inkomsten en uitgaven van de kamer Enkhuizen), 30 June 1608–29 May 1619.

3. Ibid., item no. 7142 (Journaal van inkomsten en uitgaven), 13 August 1602–9 May 1608.

4. Porsius, “Eiken en grenen,” 60.

5. Ibid., 60–61.

6. NA, Verenigde Oostindische Compagnie, item no. 7142

(Journaal van inkomsten en uitgaven), 13 August 1602–9 May 1608; and Porsius, “Eiken en grenen,” 60–61.

7. NA, Verenigde Oostindische Compagnie, item no. 7142 (Journaal van inkomsten en uitgaven), 13 August 1602–9 May 1608; and Porsius, “Eiken en grenen,” 61.

8. Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 457.

9. NA, Verenigde Oostindische Compagnie, item no. 227 (Resoluties van de ordinaris en extraordinaris vergaderingen van de kamer Amsterdam, 1602–29), 19 July 1612; item no. 228 (Resoluties van de ordinaris en extraordinaris vergaderingen van de kamer Amsterdam, 1602–29), 26 May and 13 June 1616; item no. 7287 (Minuut-uitgaande missiven van de kamer Zeeland aan autoriteiten in de Republiek en Indië), 25 July 1615; and item no. 4458 (Haags Besogne en andere commissies), 12–17 July 1685.

10. Schillemans, *De houtveilingen van Zaandam in de jaren 1655–1811*, 74.

11. Witsen, *Architectura navalis et reginem nauticum*, 199–210; and Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 35–41.

12. Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 453–54.

13. Bruijn, Gaastra, and Schöffner, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, 1:15.

14. Witsen, *Architectura navalis et reginem nauticum*, 199.

15. Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 39–40.

16. Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 453–54.

17. Ibid., 454, 454–55.

18. In 1984, Nancy Mills Reid and Ian Godfrey of the Department of Material Conservation and Restoration, Western Australian Museum, examined 11 wood samples in-house (see table 7-1). Reid concluded that she could identify 10 samples as oak, presumably European oak (*Quercus robur*). However, at the time of examination it was not possible to differentiate *Q. robur* from *Q. petraea*, as both species are nearly identical anatomically. Jansma et al., “Historische dendrochronologie in Nederland,” 6; and Mills, Unpublished report, 9 October 1985.

Recently, Caroline Vermeeren and Pauline van Rijn of BIAAX Consult identified an additional 7 samples up to genus level. BIAAX Consult is a laboratory that specializes in north-western European wood species (see table 7-2). Subsequently, Nili Liphschitz of the Botanical Laboratories of the Institute of Archaeology, Tel Aviv University, identified the same samples up to species level.

19. Liphschitz, “Dendroarchaeological Investigations”; and Van Rijn, *Analysis of Ten Wood Samples*.

20. Huber and Rouschal, *Mikrophotographischer Atlas Mediterraner Hölzer*, 21, fig. 24 (*Quercus petraea*), figs. 25–27 (*Q. robur*).
21. Van Rijn, *Analysis of Ten Wood Samples*.
22. Liphshitz, “Dendroarchaeological Investigations.”
23. Historic documentation: Witsen, *Architectura navalis et reginem nauticum*, 204; Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 35–41.
- Archaeological reports: Eenkhoorn and Wevers, *Report of an Investigation into Wood and Soil Samples*; Jansma, “Dendrochronologisch onderzoek van het V.O.C.-schip *De Amsterdam*,” 184–90; Lemée, *Renaissance Shipwrecks from Christianshavn*, 196–232; L’Hour, Long, and Rieth, “Wreck of an ‘Experimental’ Ship,” 63–73; and Maarleveld, “Archaeology and Early Modern Merchant Ships,” 164–66.
24. Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 456.
25. NA, Verenigde Oostindische Compagnie, item no. 229 (Resoluties van de ordinaris en extraordinaris vergaderingen van de kamer Amsterdam, 25 May 1628).
26. Pelsaert, *Ongeluckige voyage*, 1–2.
27. The dendrochronological examination was made by Elsemieke Hanraets, RING, Netherlands Center for Dendrochronology, Postbus 510, 8200 AM, Lelystad, Netherlands.
- Justification of dating results: RING bases its dendrochronological dating on a combination of observations: (1) comparison and relative dating (in relation to one another) of tree-ring patterns within a location or building phase; and (2) comparison of these tree-ring patterns with more than one absolutely dated reference chronology. These comparisons are both statistically and visually controlled. Observations that both support and confirm one another are considered correct.
28. Lemée, *Renaissance Shipwrecks from Christianshavn*, 117–18, 164–65, 217–18.
29. Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 456.
30. Jansma et al., “Historische dendrochronologie in Nederland,” 4, table 1 (SCH1115M); and Jansma, *RememberINGS*, 142 (NLPP).
31. Elsemieke Hanraets, letter to author, 7 February 2007; Jansma et al., “Historische dendrochronologie in Nederland,” 4, table 1 (SCH1115M); and Jansma, *RememberINGS*, 142 (NLPP).
32. Bauch and Eckstein, “Dendrochronological Dating of Oak Panels,” 45–50; Eckstein, Brongers, and Bauch, “Tree-Ring Research in the Netherlands,” 1–13; and Jansma, *RememberINGS*, 18–19, 99, 142.
33. Eckstein, Brongers, and Bauch, “Tree-Ring Research in the Netherlands,” 2, 4.
34. Jansma, *RememberINGS*, 18–19, 99, 142; and Eckstein et al., “New Evidence for the Dendrochronological Dating of Netherlandish Paintings,” 465.
35. Eckstein et al., “New Evidence for the Dendrochronological Dating of Netherlandish Paintings,” 465.
36. Ibid.
37. Ibid.; Wazny, “Aufbau und Anwendung der Dendrochronologie für Eichenholz in Polen”; Jansma et al., “Historische dendrochronologie in Nederland,” 3–4; and Jansma, *RememberINGS*, 18.
38. Eckstein et al., “New Evidence for the Dendrochronological Dating of Netherlandish Paintings,” 465; Wazny, “Aufbau und Anwendung der Dendrochronologie für Eichenholz in Polen”; and Jansma, *RememberINGS*, 18.
39. Elsemieke Hanraets, letter to author, 7 February 2007; Eckstein et al., “New Evidence for the Dendrochronological Dating of Netherlandish Paintings,” 465; and Jansma, *RememberINGS*, 18.
40. Eckstein et al., “New Evidence for the Dendrochronological Dating of Netherlandish Paintings,” 465.
41. Ibid., 465–66; Israel, *Dutch Primacy in World Trade*, 18–19; and Schillemans, *De houtveilingen van Zaandam in de jaren 1655–1811*, 3.
42. Daalder et al., *Goud uit graan*, 8; Scammell, *The World Encompassed*, 378; Veluwenkamp, “Lading voor de Oostzee,” 42–55.
43. Daalder et al., *Goud uit graan*, 8; Scammell, *The World Encompassed*, 378; Veluwenkamp, “Lading voor de Oostzee,” 42–55.
44. Haneca et al., “Provenancing Baltic Timber from Art Historical Objects,” 262.
45. Houbrechts and Pieters, “Tonnen uit Raversijde (Oostende, prov. West-Vlaanderen),” 243.
46. Schillemans, *De houtveilingen van Zaandam in de jaren 1655–1811*, 5, 15, 74.
47. Wegener Sleswyk, *De Gouden Eeuw van het fluitschip*, 27–28.
48. R. Unger, “The Fluit,” 126.
49. Bonde, Tyers, and Wazny, “Where Does the Timber Come From?,” 202.
50. Schillemans, *De houtveilingen van Zaandam in de jaren 1655–1811*, 67, 74, 67, 5.
51. Haneca et al., “Provenancing Baltic Timber from Art Historical Objects,” 263.
52. Due to the lack of historical documentation concerning wood and the trade of timber, as discussed in this chapter, there is almost no evidence for the price of oaks and other woods. Baltic oak from the Vistula region, however, must have been more expensive than other European oak since it was used for artworks and not as a bulk commodity in northwestern Europe for building construction.

53. Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 457.
54. Witsen, *Architectura navalis et reginem nauticum*, 199.
55. Lemée, *Renaissance Shipwrecks from Christianshavn*, 204, 207 (fig. 4.3.22); and Phaneuf, “Angra C,” 64, 143 (fig. 24).
56. Eckstein, Brongers, and Bauch, “Tree-Ring Research in the Netherlands,” 8.
57. Ibid.
58. Eckstein et al., “New Evidence for the Dendrochronological Dating of Netherlandish Paintings,” 465–66.
59. Zunde, “Timber Export from Old Riga,” 122–23; and Wazny, “Origin, Assortments and Transport of Baltic Timber,” 122.
60. Olechnowitz, *Der Schiffbau der Hansischen Spätzeit*, 106.
61. Albion, “Timber Problem of the Royal Navy,” 14.
62. An “average oak” refers to a century-old tree. Abell, *The Shipwright’s Trade*, 93.
63. Albion, “Timber Problems of the Royal Navy,” 14.
64. Nick Burningham, letter to author, 24 May 2007.
65. Burningham and De Jong, “The *Duyfken* Project,” 282.
66. Nick Burningham, letter to author, 24 May 2007.
67. It was initially anticipated that for the *Duiffe*’s construction approximately 200 m³ needed to be shipped as whole-sawn planks and logs flitched on either side. However, the suppliers in Latvia did less processing of the wood than originally agreed upon, which resulted in a larger volume of timber shipped to Australia. Nick Burningham, letter to author, 24 May 2007.
68. This was calculated using a density for oak of 620 kg/m³ (0.62 tons/m³). Hoadley, *Identifying Wood*, 51.
69. This number is based on the construction of 1,000 ocean-going ships in the peak year of 1640.
70. Zunde, “Timber Export from Old Riga,” 126.
71. Eckstein et al., “New Evidence for the Dendrochronological Dating of Netherlandish Paintings,” 465–66.
72. Zunde, “Timber Export from Old Riga,” 119–30; and Wazny, “Origin, Assortments and Transport of Baltic Timber,” 119.
73. Schonewille, “Nederlanders en de Oostzeecultuur,” 118–19.
74. Lindblad, “Nederland en de Oostzee, 1600–1850,” 8–27; Litwin, “Dantzig, havenstad aan de Oostzee,” 98–113; and Schonewille, “Nederlanders en de Oostzeecultuur,” 118–19.
75. Lindblad, “Nederland en de Oostzee, 1600–1850,” 15.
76. Ibid.
77. Porsius and De Munck, “Over hout, de herkomst, de kwaliteitseisen en de bewerking daarvan,” 148; and Porsius, “Hout en schepen,” 11.
78. Van Daalen and Van der Beek, “Dendroprovenancing Ship’s Timbers,” 126–28.
79. Maarleveld, Goudswaard, and Oosting, “New Data on Early Modern Dutch-Flush Shipbuilding,” 16; Lemée, *Renaissance Shipwrecks from Christianshavn*, 164–66; Van Holk, “Jaarronderzoek van scheepsresten” (1986), 23–26, 60–61, and “Jaarronderzoek van scheepsresten” (1987), 77.
80. Van Holk, “Jaarronderzoek van scheepsresten” (1986).
81. Maarleveld, Goudswaard, and Oosting, “New Data on Early Modern Dutch-Flush Shipbuilding,” 13.
82. Ibid., 16; and Van Holk, “Jaarronderzoek van scheepsresten” (1986), 61.
83. Van Holk, “Jaarronderzoek van scheepsresten” (1986), 61.
84. Maarleveld, Goudswaard, and Oosting, “New Data on Early Modern Dutch-Flush Shipbuilding,” 15–16; and Van Holk, “Jaarronderzoek van scheepsresten” (1986), 23–26, 60–61.
85. Maarleveld, Goudswaard, and Oosting, “New Data on Early Modern Dutch-Flush Shipbuilding,” 16; Van Holk, “Jaarronderzoek van scheepsresten” (1986), 23, 61, and “Jaarronderzoek van scheepsresten” (1987), 77.
86. Lemée, *Renaissance Shipwrecks from Christianshavn*, 164–66.
87. Ibid., 164–66; Van Holk, “Jaarronderzoek van scheepsresten” (1986), 23–24, and “Jaarronderzoek van scheepsresten” (1987), 77.
88. Lemée, *Renaissance Shipwrecks from Christianshavn*, 217–18, 255–56; Manders, “Mysteries of a Baltic Trader,” 320. No extensive dendrochronological study on the Scheurak SO1 has been conducted or published to date.
89. Lemée, *Renaissance Shipwrecks from Christianshavn*, 164–66; Van Holk, “Jaarronderzoek van scheepsresten” (1986), 23–24, and “Jaarronderzoek van scheepsresten” (1987), 77.
90. Several shipwrecks found closer to Poland are known to have hull timbers that match the NLARTP01 chronology well. The oldest one currently published dates to the late fourteenth century and sank in Danish waters. It seems that a single wood sample has been studied, which cross-dates best with timber from the Vistula region. It is not known from which specific hull member the sample was taken. Bonde, Tyers, and Wazny, “Where Does the Timber Come From?,” 202.
- Another example is a local logboat from the Biebrza River in eastern Poland dating to the second half of the sixteenth century. Wazny, “Baltic Timber in Western Europe,” 3.
- The Skaftö shipwreck, found in Swedish waters and dating to ca. 1440, was discovered more recently. The ship was built from Polish oak using a bottom-based construction method with lapstraked planking. The dendrochronological analysis has not yet been published. Staffan von Arbin, letter to author, 25 March 2007.
91. Bill Leonard, letter to author, 15 February 2007.
92. Ibid.

93. Witsen, *Architectura navalis et reginem nauticum*, 199; and Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 37.

94. Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 36, 37.

95. Witsen, *Architectura navalis et reginem nauticum*, 199.

96. Hollstein, *Mitteleuropäische Eichenchronologie*, 38.

97. Jansma et al., “Historische dendrochronologie in Nederland,” 12.

98. Bauch and Eckstein, “Woodbiological Investigations on Panels of Rembrandt Paintings,” 253, 259; Eckstein, Brongers, and Bauch, “Tree-Ring Research in the Netherlands,” 9; and Kuniholm, “Dendrochronology (Tree-Ring Dating) of Panel Paintings,” 211.

99. Bauch and Eckstein, “Dendrochronological Dating of Oak Panels,” 47–48; and Kuniholm, “Dendrochronology (Tree-Ring Dating) of Panel Paintings,” 211.

100. Klein, “Dendrochronologische Untersuchungen an Eichenholztafeln von Rogier van der Weyden,” 122.

101. Dry rot is actually just a common term for brown rot occurring in buildings—often in places that do not seem to have much moisture (but moisture was there when the decay occurred). Dry rot is different from soft rot, as discussed previously. Robert Blanchette, letter to author, 16 July 2008.

102. Van Beylen, *Schepen van de Nederlanden*, 24; and Sean McGrail, *Building and Trials of the Replica of an Ancient Boat*, 40–41.

103. Van Beylen, *Schepen van de Nederlanden*, 24.

104. Witsen, *Architectura navalis et reginem nauticum*, 203.

105. Bonke, “Van Amsterdam tot Japara,” 157.

106. Ibid.; Mostert, “Chain of Command,” 53; and Bruijn, Gaastra, and Schöffer, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, 1:25.

107. Bruijn, Gaastra, and Schöffer, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, 1:24.

108. Adriaan de Jong, conversation with author, 23 April 2007. De Jong remembers this practice being used in his hometown, Linschoten, during the 1950s and 1960s.

109. McGrail, *Building and Trials of the Replica of an Ancient Boat*, 40.

110. NA, Verenigde Oostindische Compagnie, item no. 229 (Resoluties van de ordinaris en extraordinaris vergaderingen van de kamer Amsterdam, 1622–29), 18 November 1627 and 25 May 1628.

111. Schillemans, *De houtveilingen van Zaandam in de jaren 1655–1811*; Van Dam, *Beschrijvinge van de Oostindische Compagnie*; Witsen, *Architectura navalis et reginem nauticum*; Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*.

112. Jansma, Hanraets, and Vernimmen, “Tree-Ring Research on Dutch and Flemish Art and Furniture,” 143, 146.

CHAPTER 8

1. NA, Verenigde Oostindische Compagnie, item no. 147 (Resoluties van de ordinaris en extraordinaris vergaderingen van de Heren XVII, 1611–30), 29 March 1626.

2. Ibid.; and ibid., item no. 7345 (Kopie-resoluties van de ordinaris en extraordinaris vergaderingen van de Heren XVII, Kamer Zeeland, 25 April 1623–22 November 1631), point 8, 18 July 1628.

3. Van IJk mentions the same length-to-beam ratio but provides more information on the height of ships and the application of the length-to-beam ratio. He explains, “The height of the ship should be one-quarter less than the beam, at the large *borstbalk* (at the upper bulwark), or said differently, where the ship is lowest. From this dimension, the depth needed for the bulwark is subtracted, which can be more or less depending on the type of ship. Then, the height of the deck below, for ships of war more than for merchant ships, but for both never more than 8 feet, leaving the remainder for the hold, which will not have enough integrity if too high, in which case beams or a *koebrug* can be added.” Ab Hoving, letters to author, 13 and 29 April 2008; Witsen, *Architectura navalis et reginem nauticum*, 104–5; and Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 53.

In the early seventeenth century, the word *koebrugge* referred to the upper or weather deck. In the later part of the century, *koebrugge* had become the term to designate the lowest continuing deck of the hull. Some two-decked ships in the seventeenth century had a partial (temporary) floor also called *koebrugge*, situated between two decks beneath the lowest gun deck, that was used as a storage place for sleeping gear and a sleeping area. This floor provided strengthening of the hull and made a ship heavier, which subsequently caused it to have a deeper draft than a ship without a *koebrugge*. *Koebrugge* could also be the spar deck between the forecabin and quarterdeck of large men-of-war, which could be used as a fighting platform. Or the *koebrugge* could be a partial deck, 4 to 5 ft below the lower deck, in three-decked naval vessels, as was applied, for example, in the construction of 19 naval vessels between 1682 and 1721. Van Beylen, *Schepen van de Nederlanden*, 39; and Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 739. Van IJk has written that the word may derive from *koybrugge*, which translates as “cabin bridge.” Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 80, 85.

4. Green, “Planking-First Construction of the VOC Ship *Batavia*,” 70.

5. Salisbury and Anderson, *Treatise on Shipbuilding*, 23.

6. Lemée, *Renaissance Shipwrecks from Christianshavn*, 202.

7. Baker and Green, “Recording Techniques Used during the Excavation of the *Batavia*,” 146.

8. Lemée, *Renaissance Shipwrecks from Christianshavn*, 174.

9. Hoving, *Nicolaes Witsens scheeps-bouw-konst open gestelt*, 102–3; Lemée, *Renaissance Shipwrecks from Christianshavn*, 176 (fig. 4.2.44); Ralåmb, *Skeps Byggerij eller Adelig Öfnings Tionde Tom*, fig. 9.
10. Hoving, *Nicolaes Witsens scheeps-bouw-konst open gestelt*, 102, 388; and Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 746.
11. Goodwin, *Construction and Fitting of the Sailing Man of War*, 53.
12. Wegener Sleswyk, *De Gouden Eeuw van het fluitschip*, 18.
13. Hoving, *Nicolaes Witsens scheeps-bouw-konst open gestelt*, 119 (fig. II.132).
14. Witsen, *Architectura navalis et reginem nauticum*, 334.
15. Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 87, 91, 289.

APPENDIX A

1. A transcription of this charter can also be found in Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 456–59; and Hoving and Emke, *Het schip van Willem Barents*, 108–12.
2. The term *overloop* also refers in the late sixteenth and seventeenth centuries to the gun deck, as Dutch ships of exploration and long-distance merchantmen had only two full decks during this period. Hence, the lower deck functioned as the gun deck. See Hoving, *Nicolaes Witsens scheeps-bouw-konst open gestelt*, 138–39; Van Beylen, *Schepen van de Nederlanden*, 39; and Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 744.
3. Van Dam has made a transcription error and mentions 30 ft instead of 13 ft. Cor Emke detected this error upon checking the original VOC manuscript in the National Archives. Hoving and Emke, *Het schip van Willem Barents*, 108.
4. Around the turn of the sixteenth to the seventeenth century, when sterncastles had become well integrated in the ship's hull, the term *boevenet* or *bovenet* (upper net) referred to the quarterdeck, as it does in this shipbuilding charter. The word *boevenet* probably originates from the time that the waist of the ship was open and an antiboarding netting or latticework could be attached to the walkways or beams in the waist to prevent the enemy from boarding a ship. In the waist, walkways connected the quarterdeck and forecastle. In the late sixteenth and early seventeenth centuries, the *boevenet* had become synonymous with a continuing quarterdeck (sometimes called halfdeck) that replaced part of the open space in the waist aft of the mainmast. By the eighteenth century, decking covered the entire waist to create a third full deck above the lower and upper decks. In this period, *boevenet* referred to the weather deck. Hoving and Emke, *Het schip van Willem Barents*, 36, 108; Van Beylen, *Schepen van de Nederlanden*, 39; and Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 728.

5. The Dutch term *open regeling* literally translates as “open railings,” which are simply the open bulwarks common on merchant ships. They had only a single thickness of planking on their exterior (and were not planked on their interior and exterior like the solid bulwarks of warships). Davies, *The Ship Model Builder's Assistant*, 30–31; and Petrejus, *Modelling The Brig-of-War Irene*, 45 (fig. 61).

6. According to Hoving and Ketting, *rochgangh* (modern Dutch, *rochgang*), or *rogboort*, refers to the open works between the topside planking of the poopdeck and the railing of the bulwark. Ketting adds that only the bulwarks of the poop and forecastle decks can be called *rogboort*. However, in Van Dam's publication it is referred to as a thick wooden railing that runs along the bulwarks, particularly on the sides of the poopdeck on which one can lean with one's arms. As the words *rogboort* and *rochgang* include the Dutch word for strake (*gang*, *boord*), which is part of the bulwarks, it could simply be the caprail (mainrail), gunwale, or the strake placed on the inside of the open bulwark directly below the caprail. See Hoving, *Nicolaes Witsens scheeps-bouw-konst open gestelt*, 388; Ketting, *Prins Willem*, 178; and Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 745.

Witsen writes that the ship should be left open between the *rock-gangen*, which also does not necessarily refer to this term as an open space. See Hoving, *Nicolaes Witsens scheeps-bouw-konst open gestelt*, 388; and Witsen, *Architectura navalis et reginem nauticum*, 117, 611.

7. The raised afterdeck is the poopdeck, whereas the fore raised deck refers to the foredeck or forecastle deck. The word *plegt* (modern Dutch, *plecht*) refers to a section of a deck or a platform, such as the helms deck (*stuurplecht*), which is part of the maindeck, or *luizeplecht*, which is a small half-moon-shaped platform directly aft of the beakhead. See Hoving, *Nicolaes Witsens scheeps-bouw-konst open gestelt*, 390; and Ketting, *Prins Willem*, 177, 180.

8. “Cross” probably refers to amidships (where the midships frame crosses the keel).

9. A 2 ft drop for each foot of length to define the angle of the sternpost is probably an error as it would create too large an angle, and other documents and charters usually refer to a 6 or 7 ft drop for the sternpost angle. Ab Hoving, letter to author, 2 May 2008.

10. *Streeck* is a recessed surface at the bottom of the sternpost, which is thinner than the rest of the sternpost, to accommodate the lowest strakes along its full width. See Hoving, *Nicolaes Witsens scheeps-bouw-konst open gestelt*, 84, 120, 390. For archaeological evidence, see Lemée, *Renaissance Shipwrecks from Christianshavn*, 154–55 (fig. 4.2.14).

11. These two knees are lodging knees fayed to the ends of each transom beam and side of the hull.

12. *Knoop* is the scarf between the stem and keel. It is also referred to as the *steven-knoop*, which is a timber that fills the obtuse-angled area between the stem and apron, most likely the deadwood. See Kooijmans and Schooneveld-Oosterling, *VOC Glossarium*, 63.

13. Again, Van Dam made an error in his transcription and mentions 15 ft instead of 50 ft. Cor Emke detected this error upon checking the original VOC manuscript in the National Archives. Hoving and Emke, *Het schip van Willem Barents*, 109.

14. *Soch* (or *zog*) refers to the place where the bottom of the ship starts rising aft and where the peak starts narrowing. See Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 751; and Kooijmans and Schooneveld-Oosterling, *VOC Glossarium*, 125.

15. *Oosterse planken* (eastern planks) are oak planks that were imported into the Lowlands from the countries on the Oostzee, or Baltic Sea. Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 457.

16. *Verscherven* means to scarf a timber in such a manner that the joints of the timbers are not all above one another but are staggered. See Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 457n5.

17. The phrase *draems wijs* refers to sawing four planks out of a foot of timber. Ab Hoving, letter to author, 2 May 2008.

18. Again, Van Dam made an error in his transcription and mentions 4 thumbs instead of 14 thumbs. Cor Emke detected this error upon checking the original VOC manuscript in the National Archives. Hoving and Emke, *Het schip van Willem Barents*, 110.

19. Hoving refers to *dael* as the pump sump, whereas Stapel interprets it in his edition of Van Dam's book as a pipe in the deck through which the pumped-up water is guided off the ship. See Hoving, *Nicolaes Witsens scheeps-bouw-konst open gestelt*, 382; and Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 730. It is most likely the *dale*, which is, according to the *Oxford English Dictionary*, "a wooden tube or trough for carrying off water, as from a ship's pump; a pump-dale."

20. Again, Van Dam made an error in his transcription and writes *stuyven*. Cor Emke detected this error upon checking the original VOC manuscript in the National Archives. Hoving and Emke, *Het schip van Willem Barents*, 110.

21. Usually the word *slemphout* is translated as "deadwood." See Lehmann, *Galleys in the Netherlands*, 52, 54. Hoving describes a *slemphout* as a straight standing knee on the inside of the stem that reinforces the stem assembly. See Hoving, *Nicolaes Witsens scheeps-bouw-konst open gestelt*, 120, 168, 389. In the *VOC Glossarium*, the word *slemphout* is described as a block inserted where stem and sternpost come together with the keel, which forms the joint between those timbers. See Kooijmans and Schooneveld-Oosterling, *VOC Glossarium*, 107. The 1603 charter

specifically states that the *slemphout* runs from the bottom to the hawse hole in the bow and the counter in the stern; it may, therefore, also refer to an apron or inner sternpost. The latter specifically applies since a *soch* is mentioned earlier in the text. A *soch* is a hog (rising wood or deadwood) to accommodate the Y-shaped floors in the stern. See Witsen, *Architectura navalis et reginem nauticum*, pl. LIX.

22. In contemporaneous Dutch shipbuilding, the maststep of the mainmast is supported by riders; the floor rider is called a *band*. See Hoving, *Nicolaes Witsens scheeps-bouw-konst open gestelt*, 119 (fig. II.132). However, in the bow where the fore maststep is placed, there may not be enough space to insert riders as a support to the mast assembly. Therefore, the term *banden* in this charter may also refer to breast hooks. In Ralåmb's manuscript on shipbuilding, dating to 1691, the term *banden* is used specifically for the breast hooks in the bow. Ralåmb, *Skeps Byggerij Eller Adelig Öfnings Tionde Tom*, 27, pl. H, nos. 16–17.

23. Again, Van Dam made an error in his transcription and mentions 4 thumbs instead of 14 thumbs. Cor Emke detected this error upon checking the original VOC manuscript in the National Archives. See Hoving and Emke, *Het schip van Willem Barents*, 110.

24. Van Dam made an error in his transcription and writes *eecken* (each). Cor Emke detected this error when he checked the original VOC manuscript in the National Archives. See *ibid.*, 111.

25. The Dutch word *deelen* (or *delen*) refers to pine planks.

26. The verb *schandekken* is used to indicate the sealing of the highest decks in the vessel by placing a covering board above the upper waterway; as a noun (*schandek*) it used to indicate the covering board itself or the deck area directly next to the bulwarks. Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 728 (bosbank), 745; and Petrejus, *Modelling The Brig-of-War Irene*, 45 (fig. 61).

27. According to Ketting, *voorscheen* is the distance from the maindeck to the bottom of the mainsail. See Ketting, *Prins Willem*, 180. However, Hoving refers to it as a bulwark. Hoving, *Nicolaes Witsens scheeps-bouw-konst open gestelt*, 391.

28. The term *vischien* may be the same as *visscher*, which is the mast hole, and refers to the beams that would support and define the rake of the mast. See Ketting, *Prins Willem*, 180. Based on Witsen's manuscript, Hoving describes it as a heavy plate with the mast hole at deck height, situated above the maststep, which could be shifted fore or aft to define the right rake of the mast. Hoving, *Nicolaes Witsens scheeps-bouw-konst open gestelt*, 391. These are mast partners; the 1603 charter specifically refers to the *vischien* being made of oak.

29. See, for explanation, Hoving, *Nicolaes Witsens scheeps-bouw-konst open gestelt*, 208, 381.

30. *Schiltbancken* are heavy support beams on which the windlass is situated. See Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 746.

31. An alliterative expression to denote all that belongs on a wooden ship, probably translates into *biels en boort*. See *ibid.*, 458.

32. The word *herdeuttelt* is a verb deriving from the plural noun *deutels*, which are dottles (treenail pegs or wedges; small square pins of oak driven in the ship's treenails to secure them in place). Before a ship was tarred, its treenails needed to be dotted (wedged). See McCarthy, *Ships' Fastenings*, 66; and Maarleveld, *Archaeological Heritage Management in Dutch Waters*, 107–8, 129.

33. One *last* equals 2 tons, weighing 2,000 kg. Bruijn, Gaastra, and Schöffer, *Dutch-Asiatic Shipping in the 17th and 18th Centuries*, 1:42–44.

34. Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 460.

35. Van Dam made an error in his transcription, as he specifies a *width* of 14 ft for the lower deck, whereas the original VOC manuscript in the National Archives states a height of 14 ft.

36. Van Dam, *Beschrijvinge van de Oostindische Compagnie*, 467.

37. *Bantweger* (modern Dutch, *bandweger*), also called *balkweger*, is the shelf clamp. This is a thick ceiling strake that supports or seats the ends of the deck beams with dovetailed

joints. See Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 81–82.

38. *Spant barchout* (modern Dutch, *berghout*) refers to the wales below the gun deck. These are essentially main wales that are the strakes of heavy planking on the side of the ship between the waterline and lower gun deck. See Goodwin, *Construction and Fitting of the Sailing Man of War*, 53.

39. Strakes of the hull planking situated between the wales.

40. Ketting, *Prins Willem*, 28 (fig. 16).

41. *Nebbe* is the horizontal arm of a knee fastened to the ship's beam. See Goodwin, *Construction and Fitting of the Sailing Man of War*, 75; and Ketting, *Prins Willem*, 29 (fig. 17).

42. *Dolboom* in this context means the same as the word *dolboord*, which refers to the ship's gunwale. See Van IJk, *De Nederlandsche scheeps-bouw-konst open gestelt*, 271–73.

43. *Waterloop* (*lijfhout*, *waterboort*) refers to a waterway. See Goodwin, *Construction and Fitting of the Sailing Man of War*, 43–44; and Ketting, *Prins Willem*, 31 (fig. 21).

APPENDIX C

1. Hollstein, *Mitteleuropäische Eichenchronologie*, 33–35.

2. Wazny, "Aufbau und Anwendung der Dendrochronologie für Eichenholz in Polen," 185–87.

3. Eckstein, Brongers, and Bauch, "Tree-Ring Research in the Netherlands," 1–13 (Chronology II).

BIBLIOGRAPHY

- Abell, Westcott. *The Shipwright's Trade*. 1948. Reprint, London: Conway Maritime Press, 1981.
- Adams, Jonathan, André F. L. van Holk, and Thijs J. Maarleveld. *Dredgers and Archaeology: Shipfinds from the Slufter*. Alphen aan den Rijn, the Netherlands: Afdeling Archeologie Onder water, Ministerie van Welzijn, Volksgezondheid en Cultuur, 1990.
- Albion, Robert G. "The Timber Problem of the Royal Navy, 1652–1862." *Mariner's Mirror* 38, no. 1 (1952): 4–22.
- American Numismatic Rarities, LLC. *The Classics Sale: The Thomas H. Sebring Collection*. Auction held on 5–6 January 2004, Orlando, FL.
- Anderson, Roger C. "The Burlesdon Ship." *Mariner's Mirror* 20, no. 2 (1934): 158–70.
- Baker, Joel, David Peate, Tod Waight, and Christine Meyzen. "Pb Isotopic Analysis of Standards and Samples Using a ²⁰⁷Pb–²⁰⁴Pb Double Spike and Thallium to Correct for Mass Bias with a Double-Focusing MC-ICP-MS." *Chemical Geology* 211 (2004): 275–303.
- Baker, Matthew. *Fragments of Ancient English Shipwrightry*. CB3 OAG-PL 2820. Manuscript in the Pepysian Library of Magdalene College, Cambridge University, ca. 1570–1630.
- Baker, Patrick E., and Jeremy N. Green. "Recording Techniques Used during the Excavation of the *Batavia*." *International Journal of Nautical Archaeology* 5, no. 2 (1976): 143–58.
- Barbour, Violet. "Dutch and English Merchant Shipping in the Seventeenth Century." *Economic History Review* 2, no. 2 (1930): 261–90.
- Barker, Richard A. "Fragments of the Pepysian Library." *Revista da Universidade de Coimbra* 32 (1986): 161–78.
- . "Many May Peruse Us: Ribbands, Moulds and Models in Dockyards." *Revista da Universidade de Coimbra* 34 (1988): 539–59.
- Bass, George F., Sheila D. Matthews, J. Richard Steffy, and Frederick H. van Doorninck Jr. *Serçe Limani: An Eleventh-Century Shipwreck*. Vol. 1, *The Ship and Its Anchorage, Crew, and Passengers*. College Station: Texas A&M University Press, 2004.
- Batavia *Daybook* 1, 17 December 1972–23 March 1973. Fremantle: Department of Maritime Archaeology, Western Australian Museum.
- Batavia *Daybook* 2, 24 March 1973–27 January 1974. Fremantle: Department of Maritime Archaeology, Western Australian Museum.
- Batavia *Daybook* 3, 28 January 1974–19 April 1974. Fremantle: Department of Maritime Archaeology, Western Australian Museum.
- Batavia *Daybook* 4, 21 December 1974–25 March 1975. Fremantle: Department of Maritime Archaeology, Western Australian Museum.
- Batavia *Daybook* 5, 25 March–1 June 1975. Fremantle: Department of Maritime Archaeology, Western Australian Museum.
- Batchvarov, Kroum N. "The Framing of Seventeenth-Century Men-of-War in England and Other Northern European Countries." Master's thesis, Texas A&M University, 2002.
- Bauch, Josef, and Dieter Eckstein. "Dendrochronological Dating of Oak Panels of Dutch Seventeenth-Century Paintings." *Studies in Conservation* 15 (1970): 45–50.
- . "Woodbiological Investigations on Panels of Rembrandt Paintings." *Wood Science and Technology* 15, no. 4 (1981): 251–63.
- Beck, Curt W., Edith C. Stout, Karen Lee, Dieter Todtenhaupt, and Andreas Kurzweil. "Ancient Pine Tar Technology: Correlations between Manufacturing Methods and Composition." In *Archaeometry 98: Proceedings of the 31st Symposium, Budapest, April 26–May 3, 1998*, 2 vols., edited by Erzsébet Jerem, Katalin T. Biró, and Edina Rudner, 2:179–84. Oxford: Archaeopress, 2002.
- Begin ende Voortganch der Vereenigde Nederlantsche Geotroyeerde Oost-Indische Compagnie: Begrypende de volgende twaelf voyagien door de inwoonderen der selviger provintien derwaerts gedaen*. 1646. Reprint, Amsterdam: Facsimile Uitgaven Nederland, 1969.
- Bonde, Niels, Ian Tyers, and Thomasz Wazny. "Where Does the Timber Come From? Dendrochronological Evidence of the Timber Trade in Northern Europe." In *Archaeological Sciences 1995: Proceedings of a Conference on the Application of Scientific Techniques to the Study of Archaeology, Liverpool, July 1995*, edited by Anthony Sinclair, Elizabeth A. Slater, and John Gowlett, 201–4. Oxbow Monograph 64. Oxford: Oxbow Books, 1997.
- Bonke, Hans. "Het eiland Onrust: Van scheepswerf van de VOC tot bedreigd historisch-archeologisch monument." In *Hollanders uit en thuis: Archeologie, geschiedenis en bouwhistorie gedurende de VOC-tijd in de Oost, de West en thuis: Cultuurhistorie van de Nederlandse expansie*, edited by Michiel H. Bartels, Erich H. P. Cordfunke, and Herbert Sarfatij, 45–60. Hilversum, the Netherlands: Verloren, 2002.

- . “Van Amsterdam tot Japara: Houtzagen voor de VOC.” In Dobber and Paul, *Cornelis Corneliszoon van Uitgeest*, 153–78.
- Bound, Mensun, Ong Soo Hin, and Nigel Pickford. “The Dutch East Indiaman *Nassau*, Lost at the Battle of Cape Rachado, Straits of Malacca, 1606.” In *Excavating Ships of War*, edited by Mensun Bound, 2:84–105. International Maritime Archaeology Series. Oswestry, UK: Anthony Nelson, 1998.
- Boxer, Charles R. *The Affair of the “Madre de Deus”: A Chapter in the History of the Portuguese in Japan*. 1929. Reprint, London: Kegan Paul, Trench, Trubner, 1929.
- Bruce, John. *Annals of the Honorable East-India Company, from Their Establishment by the Charter of Queen Elizabeth, 1600, to the Union of the London and English East-India Companies, 1707–8*. 3 vols. 1810. Reprint, Farnborough, UK: Gregg Press, 1968.
- Bruijn, Jacobus R. “The Timber Trade: The Case of Dutch-Norwegian Relations in the 17th Century.” In *The North Sea: A Highway of Economic and Cultural Exchange, Character-History*, edited by Arne Bang-Andersen, Basil Greenhill, and Egil H. Grude, 123–35. Oslo: Norwegian University Press, 1985.
- Bruijn, Jacobus R., Femme S. Gaastra, and Ivo Schöffer. *Dutch-Asiatic Shipping in the 17th and 18th Centuries: Introductory Volume*. Rijks geschiedkundige publicatiën: Uitgegeven in opdracht van de minister van onderwijs en wetenschappen onder toezicht van de Rijkscommissie voor Vaderlandse Geschiedenis, grote serie, 165. Vol. 1. The Hague: Martinus Nijhoff, 1987.
- . *Dutch-Asiatic Shipping in the 17th and 18th Centuries: Outward-Bound Voyages from the Netherlands to Asia and the Cape (1595–1794)*. Rijks geschiedkundige publicatiën: Uitgegeven in opdracht van de minister van onderwijs en wetenschappen onder toezicht van de Rijkscommissie voor Vaderlandse Geschiedenis, grote serie, 166. Vol. 2. The Hague: Martinus Nijhoff, 1979.
- . *Dutch-Asiatic Shipping in the 17th and 18th Centuries: Homeward-Bound Voyages from Asia and the Cape to the Netherlands (1597–1795)*. Rijks geschiedkundige publicatiën: Uitgegeven in opdracht van de minister van onderwijs en wetenschappen onder toezicht van de Rijkscommissie voor Vaderlandse Geschiedenis, grote serie, 167. Vol. 3. The Hague: Martinus Nijhoff, 1979.
- Brunner, Hans, and Barbara Triggs. *Hair ID: An Interactive Tool for Identifying Australian Mammalian Hair*. Collingwood, Australia: CSIRO Publishing, 2002.
- Burningham, Nick. “Round Sterns and Circular Arguments: A Response to Karl Heinz Marquardt’s “The *Duyfken* Enigma.”” *Great Circle* 29, no. 2 (2007): 16–28.
- Burningham, Nick, and Adriaan de Jong. “The *Duyfken* Project: An Age of Discovery Ship Reconstruction as Experimental Archaeology.” *International Journal of Nautical Archaeology* 26, no. 4 (1997): 277–92.
- Bushnell, Edmund. *The Compleat Ship-wright: Plainly and Demonstratively Teaching the Proportions Used by Experienced Ship-wrights according to Their Custome of Building, Both Geometrically and Arithmetically Performed: To Which Is Added, Certain Propositions in Geometry*. London: Printed by W. Leybourn for George Hurlock, 1664.
- Cappers, René T. J., Betty Mook-Kamps, Sytze Bottema, B. O. van Zanten, and Karel Vlierman. “The Analysis of Caulking Material in the Study of Shipbuilding Technology.” *Palaeohistoria* 39–40 (2000): 577–90.
- Christie’s Amsterdam B.V. *Important Gold, Silver, Jewellery and Artifacts Recovered from the Wrecks of Dutch, Spanish and English 17th, 18th and 19th Century Ships*: Hollandia, Utrecht, Slot ter Hooge, Nuestra Senora de Esperanza, *Standing Cannon Wreck*, H.M.S. Athenienne: *Dutch and Foreign Coins*. Auction held on 16 March 1983, Amsterdam.
- Clarke, Richard, Martin Dean, Gillian Hutchinson, Sean McGrail, and Jane Squirrell. “Recent Work on the R. Hamble Wreck near Burlesdon, Hampshire.” *International Journal of Nautical Archaeology* 22, no. 1 (1993): 21–44.
- Coen, Jan P. *Bescheiden omtrent zijn bedrijf in Indië*. Edited by Herman T. Colenbrander. Koninklijk Instituut voor Taal-, Land- en Volkenkunde van Nederlandsch-Indië. Vol. 1. The Hague: Martinus Nijhoff, 1919.
- . *Bescheiden omtrent zijn bedrijf in Indië*. Edited by Herman T. Colenbrander. Koninklijk Instituut voor Taal-, Land- en Volkenkunde van Nederlandsch-Indië. Vol. 2. The Hague: Martinus Nijhoff, 1920.
- . *Bescheiden omtrent zijn bedrijf in Indië*. Edited by Herman T. Colenbrander. Koninklijk Instituut voor Taal-, Land- en Volkenkunde van Nederlandsch-Indië. Vol. 3. The Hague: Martinus Nijhoff, 1921.
- . *Bescheiden omtrent zijn bedrijf in Indië*. Edited by Herman T. Colenbrander. Koninklijk Instituut voor Taal-, Land- en Volkenkunde van Nederlandsch-Indië. Vol. 4. The Hague: Martinus Nijhoff, 1922.
- . *Bescheiden omtrent zijn bedrijf in Indië*. Edited by Herman T. Colenbrander. Koninklijk Instituut voor Taal-, Land- en Volkenkunde van Nederlandsch-Indië. Vol. 5. The Hague: Martinus Nijhoff, 1923.
- . *Bescheiden omtrent zijn bedrijf in Indië*. Edited by Herman T. Colenbrander. Koninklijk Instituut voor Taal-, Land- en Volkenkunde van Nederlandsch-Indië. Vol. 7, no. 1. The Hague: Martinus Nijhoff, 1952.
- . *Bescheiden omtrent zijn bedrijf in Indië*. Edited by

- Herman T. Colenbrander. Koninklijk Instituut voor Taal-, Land- en Volkenkunde van Nederlandsch-Indië. Vol. 7, no. 2. The Hague: Martinus Nijhoff, 1953.
- Commelin, Isaac, ed. "Historische ende Journaelsche aenteyckeningh: Van 't gene Pieter van den Broecke op sijne Reysen, soo van Cabo Verde, Angola, Gunea, en Oost-Indien (aenmerckens waerdigh) voorghevalen is, etc." In *Begin ende Voortgangh der Vereenigde Nederlantsche Geoctroyeerde Oost-Indische Compagnie*, book 3, vol. 2, no. XVI, 1–110.
- . "Historisch verhael vande reyse gedaen inde Oost-Indien, met 15 schepen voor de reeckeninghe van de vereenichde gheoctroyeerde Oost-Indische Compagnie: Onder het beleydt van den vroomen ende manhaften Wybrandt van Waerwijck, als admiraal ende Sebaldt de Weert, als vice-admiraal." In *Begin ende Voortgangh van de Vereenigde Nederlantsche Geoctroyeerde Oost-Indische Compagnie*, book 2, vol. 1, no. XI, 1–88.
- . "Historisch verhael vande voyagie der Hollanderen met dry schepen gedaen naer de Oost-Indien, onder het beleydt van den Admiraal Steven vander Hagen: In den jare 1599 ende volghende." In *Begin ende Voortgangh van de Vereenigde Nederlantsche Geoctroyeerde Oost-Indische Compagnie*, book 2, vol. 1, no. VIII, 1–31.
- . "'t Historiael journael van voyagie ghedaen met drie Schepen, ghenaeamt den *Ram*, *Schaep*, ende *het Lam*, ghevaren uyt Zeelandt, van der stadt Camp-Vere, naer d'Oost-Indien, onder 't beleyt van den heer Admiraal Joris van Spilbergen, gedaen in de jaren 1601, 1602, 1603 ende 1604." In *Begin ende Voortgangh van de Vereenigde Nederlantsche Geoctroyeerde Oost-Indische Compagnie*, book 2, vol. 1, no. X, 1–62.
- . "Waerachtigh verhael van de Schipvaerd op Oost-Indien gedaen by de acht Schepen in den jare 1598: Van Amsteden uyt-ghezeylt, onder 't beleyd van den Admiraal Jacob Cornelissoon van Neck, ende Vice-Admiraal Wybrand van Warwijck." In *Begin ende Voortgangh van de Vereenigde Nederlantsche Geoctroyeerde Oost-Indische Compagnie*, book 1, vol. 1, no. III, 1–42.
- Coolhaas, W. Philippus. *Generale missiven van gouverneurs-generaal en raden aan Heren XVII der Verenigde Oostindische Compagnie*. Vol. 1 (1610–38). Rijks geschiedkundige publicatiën: Uitgegeven in opdracht van z. Exc. den minister van onderwijs, kunsten en wetenschappen, grote serie, 104. The Hague: Martinus Nijhoff, 1960.
- . *Generale missiven van gouverneurs-generaal en raden aan Heren XVII der Verenigde Oostindische Compagnie*. Vol. 2 (1639–55). Rijks geschiedkundige publicatiën: Uitgegeven in opdracht van z. Exc. de minister van onderwijs, kunsten en wetenschappen, grote serie, 112. The Hague: Martinus Nijhoff, 1964.
- Daalder, Remmelt, Els van Eyck van Heslinga, J. Thomas Lindblad, Peter Rogaar, and Peter Schonewille. *Goud uit graan: Nederland en het Oostzeegebied 1600–1850*. Zwolle, the Netherlands: Waanders Uitgevers, 1998.
- Davies, Charles G. *The Ship Model Builder's Assistant*. New York: Dover Publications, 1988.
- De Booy, A. *De derde reis van de V.O.C. naar Oost-Indië onder het beleid van admiraal Paulus van Caerden uitgezeld in 1606*. Vol. 1. De Linschoten-Vereeniging 70. The Hague: Martinus Nijhoff, 1968.
- . *De derde reis van de V.O.C. naar Oost-Indië onder het beleid van admiraal Paulus van Caerden uitgezeld in 1606*. Vol. 2. De Linschoten-Vereeniging 71. The Hague: Martinus Nijhoff, 1970.
- Deedrick, Douglas W., and Sandra L. Koch. "Microscopy of Hair Part II: A Practical Guide and Manual for Animal Hairs." *Forensic Science Communications* 6, no. 3 (2004). Available at http://www.fbi.gov/about-us/lab/forensic-science-communications/fsc/july2004/research/2004_03_research02.htm.
- De Jong, Adriaan. "Comment: 'Back to Square One: The Duyfken Strikes Back.'" *Great Circle* 29, no. 2 (2007): 3–15.
- De Jonge, Jan K. J. *De opkomst van het Nederlandsch gezag in Oost-Indië (1595–1610): Verzameling van onuitgegeven stukken uit het oud-koloniaal archief*. Vol. 1. The Hague: Martinus Nijhoff, 1862.
- Den Braven, Arjan, Saskia Broekman, Maarten Huisman, Wim Kemme, Mirjam Mostert, and Rein van't Veer. *De Buytensorgh: Onderzoek, restauratie, presentatie van een 18e eeuw VOC schip*. Amsterdam: Amsterdams Archeologisch Centrum, University of Amsterdam, 2003.
- Diekerhoff, F. L. *De oorlogsvloot in de zeventiende eeuw*. Bussum, the Netherlands: Fibula-Van Dishoeck, 1967.
- Dobber, Wladimir, and Cees Paul, eds. *Cornelis Corneliszoon van Uitgeest: Uitvinder aan de basis van de Gouden Eeuw*. Zutphen, the Netherlands: Walburg Pers, 2002.
- Drake-Brockman, Henrietta. "The Reports of Francisco Pelsaert." *Western Australian Historical Society* 5, no. 2 (1956): 1–18.
- . *Voyage to Disaster: The Life of Francisco Pelsaert*. 1963. Reprint, Crawley: University of Western Australia Press, 2006.
- Eckstein, Dieter, Johannes A. Brongers, and Josef Bauch. "Tree-Ring Research in the Netherlands." *Tree-Ring Bulletin* 35 (1975): 1–13.
- Eckstein, Dieter, Willem A. Van Es, and Ernst Hollstein. "Beitrag zur Datierung der frühmittelalterlichen Siedlung Dorestad, Holland." *Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek: Proceedings of the State Service for Archaeological Investigations in the Netherlands* 25 (1975): 165–75.

- Eckstein, Dieter, Thomasz Wazny, Josef Bauch, and Peter Klein. "New Evidence for the Dendrochronological Dating of Netherlandish Paintings." *Nature* 320 (April 1986): 465–66.
- Eenkhooorn, W., and A. J. M. Wevers. *Report of an Investigation into Wood and Soil Samples from and in the Area of the East Indiaman Amsterdam*. RIJP Rapport. Lelystad, the Netherlands: Rijksdienst voor de IJsselmeerpolders, 1983.
- Elias, Johan E. *De vlootbouw in Nederland in de eerste helft der 17e eeuw, 1596–1655*. Amsterdam: Noord-Hollandsche Uitgeversmaatschappij, 1933.
- . *Schetsen uit de geschiedenis van ons zeewezen*. Vol. 1 (1568–1652). The Hague: Martinus Nijhoff, 1916.
- Engelbrecht, Willem A., and Pieter J. van Herwerden. *De ontdekkingsreis van Jacob le Maire en Willem Cornelisz. Schouten in de jaren 1615–1617: Journalen, documenten en andere bescheiden*. 2 vols. De Linschoten-Vereeniging, 49. The Hague: Martinus Nijhoff, 1945.
- Falconer, William. *Falconer's Marine Dictionary* (1780). 1780. Reprint, Newton Abbot, UK: David and Charles, 1970.
- Fennis, Jan. *Manuel de construction des galères* (1691). Amsterdam: APA-Holland University Press, 1983.
- Floor, Willem. "Dutch Relations with the Persian Gulf." In *The Persian Gulf in History*, edited by Lawrence G. Potter, 235–59. New York: Palgrave Macmillan, 2009.
- Foster, William. *The English Factories in India, 1642–1645: A Calendar of Documents in the India Office, Westminster*. Vol. 7. Oxford: Clarendon Press, 1913.
- . *The English Factories in India, 1651–1654: A Calendar of Documents in the India Office, Westminster*. Vol. 9. Oxford: Clarendon Press, 1915.
- . *Letters Received by the East India Company from Its Servants in the East, Transcribed from the "Original Correspondence" Series of the India Office Records*. Vol. 4 (1616). 1900. Reprint, Amsterdam: Israel, 1968.
- Friel, Ian. *The Good Ship: Ships, Shipbuilding and Technology in England 1200–1520*. London: British Museum Press, 1995.
- . "Henry V's *Grace Dieu* and the Wreck in the R. Hamble near Burlesdon, Hampshire." *International Journal of Nautical Archaeology* 22, no. 1 (1993): 3–19.
- Furttenbach, Joseph. *Architectura martialis: Architectura navalis: Architectura universalis*. 1629. Reprint, Hildesheim, Germany: George Olms Verlag, 1975.
- Gaastra, Femme S. *The Dutch East India Company: Expansion and Decline*. Zutphen, the Netherlands: Walburg Pers, 2003.
- Garcia, Catarina, and Paulo Monteiro. "The Excavation and Dismantling of Angra D, a Probable Iberian Seagoing Ship, Angra Bay, Terceira Island, Azores, Portugal: Preliminary Assessment." In *Proceedings: International Symposium on Archaeology of Medieval and Modern Ships of Iberian-Atlantic Tradition: Hull Remains, Manuscripts and Ethnographic Sources: A Comparative Approach*, edited by Francisco Alves, 431–47. Lisbon: Centro Nacional de Arqueologia Náutica e Subaquática and Academia de Marinha, 1998.
- Gawronski, Jerzy H. G. *De Equipage van de Hollandia en de Amsterdam: VOC-bedrijvigheid in 18de-eeuws Amsterdam*. Amsterdam: De Bataafsche Leeuw, 1996.
- Ghisalberti, Emil L., and Ian M. Godfrey. "The Application of Nuclear Magnetic Resonance Spectroscopy to the Analysis of Pitches and Resins from Maritime Archaeological Sites." *Bulletin of the Australasian Institute for Maritime Archaeology* 14, no. 1 (1990): 1–8.
- Ghisalberti, Emil L., Ian M. Godfrey, Kiern Kilminster, Vicki L. Richards, and Emily Williams. "The Analysis of Acid-Affected Batavia Timbers." In *Proceedings of the 8th ICOM Group on Wet Organic Archaeological Materials Conference, Stockholm 2001*, edited by Per Hoffmann, James A. Spriggs, Tara Grant, Clifford Cook, and Andrea Recht, 281–307. Bremerhaven, Germany: ICOM, 2002.
- Glamann, Kristof. *Dutch-Asiatic Trade 1620–1740*. 1958. Reprint, The Hague: Martinus Nijhoff, 1981.
- Goodwin, Peter. *The Construction and Fitting of the Sailing Man of War 1650–1850*. London: Conway Maritime Press, 1987.
- Green, Jeremy N. *Australia's Oldest Wreck: The Historical Background and Archaeological Analysis of the Wreck of the English East India Company's Ship Trial, Lost off the Coast of Western Australia in 1622*. BAR Supplementary Series 27. Oxford: British Archaeological Reports, 1977.
- . *The Loss of the Verenigde Oostindische Compagnie Jacht Vergulde Draeck, Western Australia 1656: A Historical Background and Excavation Report with an Appendix on Similar Loss of the Fluit Lastdrager*. 2 vols. BAR Supplementary Series 36. Oxford: British Archaeological Reports, 1977.
- . *The Loss of the Verenigde Oostindische Compagnie Retourschip Batavia, Western Australia 1629: An Excavation Report and Catalogue of Artifacts*. BAR International Series 489. Oxford: British Archaeological Reports, 1989.
- . "The Planking-First Construction of the VOC Ship Batavia." In *Carvel Construction Technique: Skeleton-First, Shell-First: Proceedings of the Fifth International Symposium on Boat and Ship Archaeology, Amsterdam 1988*, edited by H. Reinder Reinders and Kees Paul, 70–71. Oxbow Monograph 12. Oxford: Oxbow Books, 1991.
- . "The Survey of the VOC Fluit *Risdam* (1727), Malaysia." *International Journal of Nautical Archaeology* 15, no. 2 (1986): 93–104.
- . "Vergulde Draeck Excavation 1981." *Bulletin of the Institute of Maritime Archaeology* 5 (1981): 46–47.

- . “The Vergulde Draeck Excavation 1981 and 1983.” *Bulletin of the Australian Institute for Maritime Archaeology* 7, no. 2 (1983): 1–8.
- . “The VOC Ship *Batavia* Wrecked in 1629 on the Houtman Abrolhos, Western Australia.” *International Journal of Nautical Archaeology* 4, no. 1 (1975): 43–63.
- . “The Wreck of the Dutch East Indiaman the *Vergulde Draeck*, 1656.” *International Journal of Nautical Archaeology* 2, no. 2 (1973): 267–89.
- Habermehl, Nico. *Scheepswrakken in de Waddenzee (1500–1900)*. Lelystad, the Netherlands: Nederlands Instituut voor Scheeps- en onderwaterArcheologie, Rijksdienst voor het Oudheidkundig Bodemonderzoek (NISA/ROB), 2000.
- Hall, Jerome L. “A Seventeenth-Century Northern European Merchant Shipwreck in Monte Cristi Bay, Dominican Republic.” PhD diss., Texas A&M University, 1996.
- Haneca, Kristof, Thomasz Wazny, Joris van Acker, and Hans Beeckman. “Provenancing Baltic Timber from Art Historical Objects: Success and Limitations.” *Journal of Archaeological Science* 32 (2005): 261–71.
- Harland, John H. “Note: Piet Heyn and the Early Use of Copper Sheathing.” *Mariner’s Mirror* 62, no. 1 (1976): 1–2.
- Harris, Daniel G. *F. H. Chapman: The First Naval Architect and His Work*. London: Conway Maritime Press, 1989.
- Heeres, Jan E., ed. *Dagh-register gehouden int Casteel Batavia vant passerende daer ter plaetse als over geheel Nederlands-India, anno 1624–1629*. The Hague: Martinus Nijhoff, 1896.
- Historisch genootschap. “Twaalfde vergadering: 26 November 1871: Verhaal van eenige oorlogen in Indië, 1622: Uit het archief van Hilten.” *Kroniek van het historisch genootschap, gevestigd te Utrecht* 27, no. 6.2 (1872): 536–76. Utrecht: Kemink en zoon, 1872.
- Hoadley, R. Bruce. *Identifying Wood: Accurate Results with Simple Tools*. Newton, CT: Taunton Press, 1990.
- Hocker, Frederick M. “Bottom-Based Shipbuilding in Northwestern Europe.” In *The Philosophy of Shipbuilding: Conceptual Approaches to the Study of Wooden Ships*, edited by Frederick M. Hocker and Cheryl A. Ward, 65–94. College Station: Texas A&M University Press, 2004.
- Hollstein, Ernst. *Mitteuropäische Eichenchronologie*. Trierer Grabungen und Forschungen. Vol. XI. Rheinisches Landesmuseum Trier. Mainz am Rhein, Germany: Verlag Philipp von Zabern, 1980.
- Honig, Gerrit J. “De molens van Amsterdam: De invloed van de molens op het industriele leven in de Gouden Eeuw.” *Jaarboek van het genootschap Amstelodamum* 27 (1930): 79–159.
- Houbrechts, David, and Marnix Pieters. “Tonnen uit Raversijde (Oostende, prov. West-Vlaanderen): Een goed gedateerd verhaal over water- en andere putten.” *Archeologie in Vlaanderen* 5 (1995–96): 225–61.
- Hoving, Ab. “Drawing the Line, or Why the Rotterdam Shipwrights Would Not Adopt the Amsterdam (English) Drafting Techniques.” *Nautical Research Journal* 52, no. 2 (2007): 67–81.
- . “Dutch Shipbuilding in the Seventeenth Century.” *Nautical Research Journal* 53, no. 1 (2008): 19–30.
- . *Nicolaes Witsens scheeps-bouw-konst open gesteld*. Franeker, the Netherlands: Van Wijnen, 1994.
- Hoving, Ab J., and Cor Emke. *Het schip van Willem Barents: Een hypothetische reconstructie van een laat-zestiende-eeuws jacht*. Hilversum, the Netherlands: Verloren, 2004.
- Hoving, Ab J., and Alan A. Lemmers. *In tekening gebracht: De achttiende-eeuwse scheepsbouwers en hun ontwerpmethoden*. Amsterdam: De Bataafse Leeuw, 2001.
- Hoving Ab J., and Robert Parthesius. “Hollandse scheepsbouwmethoden in de zeventiende eeuw.” In *Herbouw van een Oostindievaarder: Batavia Cahier 3*, edited by Robert Parthesius, 5–11. Lelystad, the Netherlands: Stichting Nederland bouwt een VOC-retourschip, 1991.
- Huber, Bruno, and Christine Rouschal. *Mikrophotographischer Atlas Mediterraner Hölzer*. Berlin-Grunewald, Germany: Fritz Haller Verlag, 1954.
- Hundley, Paul. “Batavia Reconstruction.” In *Proceedings of the Second Southern Hemisphere Conference on Maritime Archaeology*, edited by William Jeffery and Jenifer Amess, 249–59. Adelaide: South Australian Department of Environment and Planning and Commonwealth Department of Home Affairs and Environment, 1983.
- IJzerman, Jan W. *De Reis om de Wereld door Olivier van Noort, 1598–1601*. Vol. 1. De Linschoten-Vereeniging, 27. The Hague: Martinus Nijhoff, 1926.
- Ingelman-Sundberg, Catherina. “The VOC Ship *Batavia* 1629: Report on the Third Season of Excavation.” *Australian Archaeology* 3 (1975): 45–53.
- Israel, Jonathan I. *Dutch Primacy in World Trade 1585–1740*. Oxford: Clarendon Press, 1989.
- . *The Dutch Republic: Its Greatness, and Fall 1477–1806*. 1995. Reprint, Oxford: Clarendon Press, 1998.
- Janse, Herman. “Bouwbedrijf en houtgebruik in het verleden: Eikehout en naaldhout als bouw materiaal.” *Houtvoorlichting* (October 1960): 15–45.
- Jansma, Esther. “Dendrochronologisch onderzoek van het V.O.C.-schip de *Amsterdam*.” *Westerheem* 36 (1987): 184–90.
- . *RemembeRINGS: The Development and Application of Local and Regional Tree-Ring Chronologies of Oak for the Purposes of Archaeological and Historical Research in the Netherlands*. Nederlandse Archeologische Rapporten

19. Amersfoort, the Netherlands: Rijksdienst voor het Oudheidkundig Bodemonderzoek, 1995.
- Jansma, Esther, Elsemieke Hanraets, and Tamara Vernimmen. "Tree-Ring Research on Dutch and Flemish Art and Furniture." In *TRACE: Tree Rings in Archaeology, Climatology and Ecology*, edited by Esther Jansma, Achim Bräuning, Holger Gärtner, and Gerhard Schleser, 139–46, vol. 2, *Proceedings of the Dendrosymposium 2003, 1–3 May 2003, Utrecht, the Netherlands*. Jülich, Germany: Forschungszentrum, Zentralbibliothek, 2004.
- Jansma, Esther, Ute Sass-Klaassen, Dirk J. de Vries, and Elsemieke Hanraets. "Historische dendrochronologie in Nederland: De stand van zaken anno 2001." In *Praktijkboek Instandhouding Monumenten*, edited by Jaap M. van der Veen and Stef Binst, 2–15. Vol. 3, no. 4 (*Diverse onderwerpen*, issue 9, February 2002). The Hague: SDU Uitgevers, 2002.
- Ketting, Herman. Prins Willem: *Een zeventiende-eeuwse Oostindiëvaarder*. Bussum, the Netherlands: Unieboek, 1979.
- Keuning, Johannes, ed. *De tweede schipvaart der Nederlanders naar Oost-Indië onder Jacob Cornelisz. van Neck en Wybrant Warwijck, 1598–1600*. Vol. 1. De Linschoten-Vereeniging 42. The Hague: Martinus Nijhoff, 1938.
- . *De tweede schipvaart der Nederlanders naar Oost-Indië onder Jacob Cornelisz. van Neck en Wybrant Warwijck, 1598–1600*. Vol. 2. De Linschoten-Vereeniging 44. The Hague: Martinus Nijhoff, 1940.
- . *De tweede schipvaart der Nederlanders naar Oost-Indië onder Jacob Cornelisz. van Neck en Wybrant Warwijck, 1598–1600*. Vol. 5, no. 1. De Linschoten-Vereeniging 50. The Hague: Martinus Nijhoff, 1947.
- Kingma, Jur. "De wereld van hout en mechanische zagerij." In Dobber and Paul, *Cornelis Corneliszoon van Uitgeest*, 59–84.
- Kingma, Vibeke. "De betekenis van de uitvindingen van Cornelis Corneliszoon voor de Nederlandse nijverheid." In Dobber and Paul, *Cornelis Corneliszoon van Uitgeest*, 125–36.
- Klein, Peter. "Dendrochronologische Untersuchungen an Eichenholztäfelchen von Rogier van der Weyden." *Jahrbuch der Berliner Museen* 23 (1981): 113–23.
- Kooijmans, Marc, and Judith Schooneveld-Oosterling. *VOC Glossarium: Verklaringen van termen, verzameld uit de Rijks geschiedkundige publikatiën die betrekking hebben op de Verenigde Oost-Indische Compagnie*. The Hague: Instituut voor Nederlandse Geschiedenis, 2000.
- Kühn, Hermann. "Detection and Identification of Waxes, including Punic Wax, by Infra-red Spectrography." *Studies in Conservation* 5, no. 2 (1960): 71–81.
- Kuniholm, Peter I. "Dendrochronology (Tree-Ring Dating) of Panel Paintings." In *The Science of Paintings*, edited by W. Stanley Taft and James W. Mayer, 206–15, 225–26. New York: Springer, 2000.
- La Fleur, James D. *Pieter van den Broecke's Journal of Voyages to Cape Verde, Guinea and Angola (1605–1612)*. The Hakluyt Society 3, no. 5. London: Hakluyt Society, 2000.
- Larn, Richard, ed. "The Wreck of the Dutch East Indiaman *Campen* on the Needles Rocks, Isle of Wight, 1627—Part 1." *International Journal of Nautical Archaeology* 14, no. 1 (1985): 1–31.
- . "Wrecks round the Scillies." In *Buried and Sunken Treasure: Amazing Discoveries of Modern Times*, edited by Windsor Chorlton, 5–33. London: Marshall Cavendish, 1974.
- Larn, Richard, and Bridget Larn. *Shipwreck Index of the British Isles*. Vol. 1. London: Lloyd's Register of Shipping, 1995.
- Lehmann, Louis Th. *Galleys in the Netherlands*. Amsterdam: Meulenhoff, 1984.
- Lemée, Christian P. P. *The Renaissance Shipwrecks from Christianshavn: An Archaeological and Architectural Study of Large Carvel Vessels in Danish Waters, 1580–1640*. Ships and Boats of the North, vol. 6. Roskilde, Denmark: The Viking Ship Museum, 2006.
- Lemmers, Alan A. *Techniek op schaal: Modellen en het technologiebeleid van de Marine 1725–1885*. Amsterdam: De Bataafse Leeuw, 1996.
- L'Hermite, Jacques. "Journael van de Nassausche Vloot: Ofte beschrijvingh van de voyagie om den gantschen aerdkloot, gedaen met elf schepen: Onder 't beleydt van den Admiraal Iaques L'Heremite, ende Vice-Admiraal Gheen Huygen Schapendam, in den jaren 1623, 1624, 1625 en 1626." Edited by Isaac Commelin. In *Begin ende Voortgangh der Vereenigde Nederlantsche Geootroyeerde Oost-Indische Compagnie*, book 4, vol. 2, no. IXX, 1–79.
- L'Hermite de Jonge, Jacques. *Breeder verhael ende klare beschrijvinge van tghene den admiraal Cornelis Matelief de Jonge inde Oost-Indien voor de stadt Malacca, ende int belegg der zelve wedervaren is: Als ooc den vreesselijcke strijdt ter zee, tusschen den admiraal voorsz. ende de Portugijsen, ende andere gheschiedenissen meer: Overgheschreven by eenen der commisen inde vlote*. Rotterdam: Jan Jansz, 1608.
- L'Honoré Naber, Samuel P. *Reizen van Willem Barents, Jacob van Heemskerck, Jan Cornelisz Rijp en anderen naar het Noorden, 1594–1597*. Edited by Gerrit de Veer. 2 vols. De Linschoten-Vereeniging 14 and 15. The Hague: Martinus Nijhoff, 1917.
- . "'t Leven en bedrijf van vice-admiraal de With, zaliger." In *Bijsdragen en mededeelingen van het Historisch Genootschap (gevestigd te Utrecht)*, 47:47–169. Utrecht: Kemink, 1926.
- L'Hour, Michel, Luc Long, and Eric Rieth. *Le Mauritius: La mémoire engloutie*. Paris: Casterman, 1989.
- . "The Wreck of an 'Experimental' Ship of the 'Oost-

- Indische Compagnie: The *Mauritius* (1609)." *International Journal of Nautical Archaeology* 19, no. 1 (1990): 63–73.
- Lightley, Robert A. "An 18th Century Dutch East Indiaman Found at Cape Town, 1971." *International Journal of Nautical Archaeology* 5, no. 4 (1976): 305–16.
- Lindblad, J. Thomas "Nederland en de Oostzee, 1600–1850." In Daalder et al., *Goud uit graan*, 8–27.
- Liphschitz, Nili. "Dendroarchaeological Investigations: *Batavia*, *Vergulde Draak*, *Zuiddorp* and *Zeewijk* Shipwrecks." Report 513, unpublished. Tel Aviv, Israel: Botanical Laboratories, Institute of Archaeology, Tel Aviv University, 2009.
- Litwin, Jerzy. "Dantzig, havenstad aan de Oostzee." In Daalder et al., *Goud uit graan*, 98–113.
- Loewen, Brad. "Resinous Paying Materials in the French Atlantic, AD 1500–1800." *IJNA* 34, no. 2 (2005): 238–52.
- Maarleveld, Thijs J. *Archaeological Heritage Management in Dutch Waters: Exploratory Studies*. Scheepsarcheologie V (Flevobericht 411). Ketelhaven, the Netherlands: Nederlands Instituut voor Scheeps- en onderwaterArcheologie, Rijksdienst Oudheidkundig Bodemonderzoek (NISA/ROB), 1998.
- . "Archaeology and Early Modern Merchant Ships: Building Sequence and Consequences: An Introductory Review." In *Rotterdam Papers VII: A Contribution to Medieval Archaeology*, edited by Arnold Carmiggelt, 155–73. Rotterdam: Bureau Oudheidkundig Onderzoek van Gemeentewerken, 1992.
- . "Double Dutch Solutions in Flush-Planked Shipbuilding: Continuity and Adaptations at the Start of Modern History." In *Crossroads in Ancient Shipbuilding: Proceedings of the Sixth International Symposium on Boat and Ship Archaeology, Roskilde 1991*, edited by Christer Westerdahl, 153–63. International Symposium on Boat and Ship Archaeology (ISBSA) 6. Oxbow Monograph 40. Oxford: Oxbow Books, 1994.
- . "Het schip Scheurak SO1: Een scheepsopgraving in de Waddenzee." *Spiegel Historiael* 25, no. 12 (1990): 573–77.
- . "Schiffsarchäologie im Wattenmeer." *Das Logbuch* 26, no. 3 (1990): 103–7.
- Maarleveld, Thijs J., Boudewijn Goudswaard, and Rob Oosting. "New Data on Early Modern Dutch-Flush Shipbuilding: Scheurak T24 and Inschot/Zuidoostrak." *International Journal of Nautical Archaeology* 23, no. 1 (1994): 13–25.
- MacLeod, Ian D. "Conservation of Waterlogged Timbers from the *Batavia* 1629." *Bulletin of the Australian Institute for Maritime Archaeology* 14, no. 2 (1990): 1–8.
- Manders, Martijn R. "The BZN 10-Wreck, Threatened by Nature?" *Bulletin of the Australasian Institute for Maritime Archaeology* 26 (2002): 99–104.
- . "The Mysteries of a Baltic Trader." In *Boats, Ships, and Shipyards: Proceedings of the Ninth International Symposium on Boat and Ship Archaeology, Venice 2000*, edited by Carlo Beltrame, 320–28. International Symposium on Boat and Ship Archaeology (ISBSA) 9. Oxford: Oxbow Books, 2003.
- . "Raadsels rond een gezonken oostzeevaarder." In Daalder et al., *Goud uit graan*, 70–81.
- Marguerie, Dominique, and Jean-Yves Hunot. "Charcoal Analysis and Dendrology: Data from Archaeological Sites in North-Western France." *Journal of Archaeological Science* 34, no. 9 (2007): 1417–33.
- Markham, Clements R. *The Hawkins' Voyages during the Reigns of Henry VIII, Queen Elizabeth, and James I*. The Hakluyt Society 2, no. 57. London: Hakluyt Society, 1878.
- Marquardt, Karl H. "The *Duyfken* Enigma: Some Alternative Design Possibilities." *Great Circle* 29, no. 1 (2007): 41–57.
- Marsden, Peter. "The Wreck of the Dutch East Indiaman *Amsterdam* near Hastings, 1749: An Interim Report." *International Journal of Nautical Archaeology* 1, no. 1 (1972): 73–96.
- Matelief de Jonge, Cornelis. *An Historicall and True Discourse, of a Voyage Made by the Admirall Cornelis Matelife the Yonger into the East Indies, Who Departed out of Holland, in May 1605: With the Besieging of Malacca, and the Battaile by Him Fought at Sea against the Portugales in the Indies, with Other Discourses*. London: William Barret, 1608.
- . "Historische verhael vande treffelijcke reyse, gedaen naer de Oost-Indien ende China met elf Schepen: Door den manhaften Admiraal Cornelis Matelief de Jonge: Inden jaren 1605, 1606, 1607, ende 1608." Edited by Isaac Commelin. In *Begin ende Voortganch der Vereenigde Nederlandsche Geotroyeerde Oost-Indische Compagnie*, book 3, vol. 2, no. XIII, 1–191.
- Matthee, Rudolph P. *The Politics of Trade in Safavid Iran: Silk for Silver, 1600–1730*. Cambridge Studies in Islamic Civilization. Cambridge: Cambridge University Press, 1999.
- May, Jan C. *De reis van Jan Cornelisz. May naar de IJszee en de Amerikaansche kust, 1611–1612*. Edited by Samuel Muller. De Linschoten-Vereeniging 1. The Hague: Martinus Nijhoff, 1909.
- McCarthy, Michael. "Ship Fastenings (A Preliminary Study)." *Bulletin of the Australian Institute for Maritime Archaeology* 7, no. 1 (1983): 1–24.
- . *Ships' Fastenings: From Sewn Boat to Steamship*. College Station: Texas A&M University Press, 2005.
- McGrail, Sean. *The Building and Trials of the Replica of an Ancient Boat: The Gokstad Faering. Part 1: Building the Replica*. Maritime Monographs and Reports, no. 11. Greenwich: National Maritime Museum, 1974.

- Meijer, Puck. *Leer in beeld: En toen was er een schoen*. Waalwijk, the Netherlands: Nederlands Leder en Schoenen Museum, 1992.
- Meyrelles do Souto, António de Azevedo. "Hystorya dos cercos que os Olandezes puzerão à Fortaleza de Mozambique o anno de 607 e 608." *Studia* 12 (July 1963): 465–548.
- Mills, Nancy R. Unpublished reports. Department of Material Conservation and Restoration. Fremantle: Western Australian Museum, 8 June, 13 June, and 9 October 1983.
- Moree, Perry. *Dodo's en galjoenen: De reis van het schip Gelderland naar Oost-Indië, 1601–1603*. De Linschoten-Vereeniging 100. Zutphen, the Netherlands: Walburg Pers, 2001.
- Mostert, Tristan. "Chain of Command: The Military System of the Dutch East India Company 1655–1663." Master's thesis, University of Leiden, 2007.
- Muckelroy, Keith W., ed. *Archeology under Water: An Atlas of the World's Submerged Sites*. New York: McGraw-Hill, 1980.
- Murray, Cristian. "The Interpretation of the Anglo-Dutch East-Indiaman *Avondster* Ship's Construction." In *Avondster Project: Excavation Report of the VOC Ship Avondster*, edited by Robert Parthesius, 131–53. Amsterdam: Centre for International Heritage Activities, 2007.
- National Archives (NA) of the Netherlands. *Admiraliteitscolleges*. Reference code 1.01.46. The Hague.
- . *Archieven van de Verenigde Oostindische Compagnie, 1602–1795*. Reference code 1.04.02. The Hague.
- Olechnowicz, Karl F. *Der Schiffbau der Hansischen Spätzeit: Eine Untersuchung zur Sozial- und Wirtschaftsgeschichte der Hanse*. Weimar, Germany: Hermann Böhlaus Nachfolger, 1960.
- Oppenheim, Michael. "The Royal and Merchant Navy under Elizabeth." *English Historical Review* 6, no. 23 (1891): 465–94.
- Overmeer, Alice. "Searching for the Missing Link? A Research on Clinker Built Ships in the 15th and 16th Centuries." In *SOJAbundel 2006*, edited by Ellen Gehring, 63–72. Amsterdam: Symposium voor Onderzoek door Jonge Archeologen, 2006.
- Pang, James T. T. "The Treatment of Waterlogged Timbers from a 17th Century Dutch East Indiaman, *Batavia*, Using Polyethylene Glycol." In *ICOM Committee for Conservation, 6th triennial meeting, Ottawa, 1–6 July 1981*, 1–13. Paris: ICOM, 1981.
- Pare, Christopher F. E., ed. *Metals Make the World Go Round: The Supply and Circulation of Metals in Bronze Age Europe: Proceedings of a Conference Held at the University of Birmingham in June 1997*. Oxford: Oxbow, 2000.
- Parmentier, Jan, Karel Davids, and John Everaert. *Peper, plancius en porselein: De reis van het schip Swarte Leeuw naar Atjeh en Bantam, 1601–1603*. De Linschoten-Vereeniging 101. Zutphen, the Netherlands: Walburg Pers, 2003.
- Parthesius, Robert. "De *Batavia*, een retourschip van de VOC." In *De Batavia te water*, edited by Vibeke Roeper, Robert Parthesius, and Lodewijk Wagenaar, 57–98. Amsterdam: De Bataafsche leeuw, 1996.
- . "De dubbele huid van Oostindievaarders aan het begin van de 17de eeuw." In *Herbouw van een Oostindievaarder: Batavia Cahier 3*, edited by Robert Parthesius, 25–29. Lelystad, the Netherlands: Stichting Nederland bouwt een VOC-retourschip, 1991.
- . "Dutch Ships in Tropical Waters: The Development of the Dutch East India Company (VOC) Shipping Network in Asia 1595–1660." PhD diss., University of Amsterdam, 2007.
- . "Het huiddicht en van de wegering in het gemeen." In *Herbouw van een Oostindievaarder: Batavia Cahier 5*, edited by Robert Parthesius, 7–20. Lelystad, the Netherlands: Stichting Nederland bouwt een VOC-retourschip, 1994.
- . "Het wrak van VOC-schip *Avondster* in de haven van Galle (Sri Lanka): Een potentiële bron van kennis over de Europese expansie in Azië." In *Hollanders uit en thuis: Archeologie, geschiedenis en bouwhistorie gedurende de VOC-tijd in de Oost, de West en thuis: Cultuurhistorie van de Nederlandse expansie*, edited by Michiel H. Bartels, Erich H. P. Cordfunke, and Herbert Sarfatij, 61–70. Hilversum, the Netherlands: Verloren, 2002.
- Parthesius, Robert, Karen Millar, Somasiri Devendra, and Jeremy N. Green, eds. *Sri Lanka Maritime Archaeological Unit Report on the Avondster Project 2001–2002*. Amsterdam: Amsterdams Historisch Museum, 2003.
- Pelsaert, E. François. *Ongeluckige voyage, van 't schip Batavia, nae de Oost-Indien: Gebleven op de Abrolhos van Frederick Houtman, op de hooghte van 28<F>1/3</F>-graet, by zuyden de linie Aequinoctiael. Uytgevaren onder den E. Francoys Pelsert*. Amsterdam: Jan Jansz, 1647.
- Petersen, Britt-Marie. "The Dutch Fluitship *Anna Maria*, Foundered in Dalarö Harbour in 1709." *International Journal of Nautical Archaeology* 16, no. 4 (1987): 293–304.
- Petrijus, E. W. *Modelling the Brig-of-War Irene: A Handbook for the Building of Historical Ship-Models*. Hengelo, the Netherlands: De Esch, 1970.
- Phaneuf, Erik. "Angra C, une épave hollandaise en contexte açoréen du XVIIe siècle." Master's thesis, Université de Montréal, 2003.
- Porsius, Nanning. "Eiken en grenen." In *Herbouw van een Oostindievaarder: Batavia Cahier 5*, edited by Robert Parthesius, 57–64. Lelystad: Stichting Nederland bouwt een VOC-retourschip, 1994.
- . "Hout en schepen." *Zaans Erfgoed* 1, no. 2 (2002): 10–13.
- Porsius, Nanning, and Eric de Munck. "Over hout, de herkomst,

- de kwaliteitseisen en de bewerking daarvan." In Dobber and Paul, *Cornelis Corneliszoon van Uitgeest*, 137–52.
- Price, Richard, and Keith Muckelroy. "The Kennemerland Site: The Third and Fourth Seasons 1974 and 1976: An Interim Report." *International Journal of Nautical Archaeology* 6, no. 3 (1977): 187–218.
- Pyrard, François. *The Voyage of François Pyrard of Laval to the East Indies, the Maldives, the Moluccas and Brazil*, translated by Albert Gray. Vol. 1. The Hakluyt Society 1, no. 76. London: Hakluyt Society, 1887.
- . *The Voyage of François Pyrard of Laval to the East Indies, the Maldives, the Moluccas and Brazil*, translated by Albert Gray. Vol. 2, no. 1. The Hakluyt Society 1, no. 77. London: Hakluyt Society, 1888.
- . *The Voyage of François Pyrard of Laval to the East Indies, the Maldives, the Moluccas and Brazil*, translated by Albert Gray. Vol. 2, no. 2. The Hakluyt Society 1, no. 80. London: Hakluyt Society, 1890.
- Ralåmb, Åke C. *Skeps Byggerij eller Adelig Öfnings Tionde Tom*. 1691. Reprint, Malmö: A. B. Malmö Ljustrycksanstalt, 1943.
- Richards, Vicki L. "The Consolidation of Degraded Deacidified Batavia Timbers." *AICCM Bulletin* 16, no. 3 (1990): 35–52.
- . "Cosmetic Treatment of Deacidified Batavia Timbers." *AICCM Bulletin* 27 (2002): 12–13.
- Rietbergen, Petrus J. A. N. *De eerste landvoogd Pieter Both (1568–1615): Gouverneur-generaal van Nederlands-Indië (1609–1614)*. 2 vols. De Linschoten-Vereeniging 86–87. Zutphen, the Netherlands: De Walburg Pers, 1987.
- Rittenhouse, Kevin D. "Mitochondrial DNA Control Region Sequences Used for Identification of Species in Two Forensic Science Case Studies: The Monte Cristi Shipwreck and a Homicide Case." Master's thesis, Texas A&M University, 1996.
- Roep, Vibeke. *De schipbreuk van de Batavia, 1629*. De Linschoten-Vereeniging 92. Zutphen, the Netherlands: Walburg Pers, 1993.
- Ronnberg, Erik A. R., Jr. "The Coppering of 19th Century American Merchant Sailing Ships: Some Historical Background with Notes for Modelmakers." *Nautical Research Journal* 26, no. 3 (1980): 125–48.
- Rouffaer, Gerret P., and Jan W. IJzerman, eds. *De Eerste Schipvaart der Nederlanders naar Oost-Indië onder Cornelis de Houtman, 1595–1597*. De Linschoten-Vereeniging 7. The Hague: Martinus Nijhoff, 1915.
- . *De Eerste Schipvaart der Nederlanders naar Oost-Indië onder Cornelis de Houtman, 1595–1597*. De Linschoten-Vereeniging 25. The Hague: Martinus Nijhoff, 1925.
- Royal Society of London. "An Extract of a Letter, Written from Holland, about Preserving of Ships Being Worm-Eaten." *Philosophical Transactions* 1, no. 11 (1665–66): 190–91.
- Ryder, Michael L. "Animal Hair in Medieval Ship Caulking Throws Light on Livestock Types." *Environmental Archaeology* 2 (1998): 61–66.
- Sainsbury, Ethel B. *A Calendar of the Court Minutes, etc., of the East India Company, 1640–1643*. Vol. 2. Oxford: Clarendon Press, 1909.
- Salisbury, William, and Roger C. Anderson, eds. *A Treatise on Shipbuilding and a Treatise on Rigging Written about 1620–1625*. Society for Nautical Research Occasional Papers, no. 6. London: Society for Nautical Research, 1958.
- Salville, R. V. "3. The Management of the Royal Dockyards, 1672–1678." In *The Naval Miscellany*, edited by N. A. M. Rodger, 5:94–142. Publications of the Navy Records Society, vol. 125. London: Navy Records Society, 1984.
- Scammell, Geoffrey V. *The World Encompassed: The First European Maritime Empires c. 800–1650*. London: Methuen, 1981.
- Schillemans, Cornelis A. *De houtveilingen van Zaandam in de jaren 1655–1811*. The Hague: Martinus Nijhoff, 1947.
- Schonewille, Peter. "Nederlanders en de Oostzeecultuur." In Daalder et al., *Goud uit graan*, 114–29.
- Shimada, Ryuto. *The Intra-Asian Trade in Japanese Copper by the Dutch East India Company during the Eighteenth Century*. Edited by Leonard Blussé and Hendrik E. Niemeijer. Tanap Monographs on the History of the Asian-European Interaction, vol. 4. Leiden, the Netherlands: Brill, 2006.
- Sigmond, J. Peter, and Lous H. Zuiderbaan. *Dutch Discoveries of Australia: Early Voyages and Shipwrecks off the West Coast*. 1976. Reprint, Amsterdam: Batavian Lion, 1995.
- Sotheby & Co. *Catalogue of Treasure Recovered off the Shetland Isles Comprising Gold and Silver Coins and Important Artifacts from the Wrecks of the Wendela, Danish Asiatic Company (Lost 1737), the Lastdrager, Dutch East India Company (Lost 1653), the Curaçao, Admiralty of Amsterdam (Lost 1729), the Evstafii, Imperial Russian Navy (Lost 1780)*. Auction held 8 November 1973, London.
- Steffy, J. Richard. *Wooden Ship Building and the Interpretation of Shipwrecks*. 1994. Reprint, College Station: Texas A&M University Press, 1998.
- Sténuit, Robert. "Early Relics of the VOC Trade from Shetland: The Wreck of the Flute *Lastdrager* Lost off Yell, 1653." *International Journal of Nautical Archaeology* 3, no. 2 (1974): 213–56.
- . "The Sunken Treasure of St. Helena." *National Geographic* 154, no. 4 (October 1978): 562–76.
- . "De Witte Leeuw: De schipbreuk van een schip van de V.O.C. in 1613 en het onderwateronderzoek naar het wrak in 1976." *Bulletin van het Rijksmuseum* 25, no. 4 (1977): 165–78.
- Sundblad, K. "A Genetic Reinterpretation of the Falun and

- Åmmeberg Ore Types, Bergslagen, Sweden." *Mineralium Deposita* 29, no. 2 (1994), 170–79.
- Supple, B. E. "Currency and Commerce in the Early Seventeenth Century." *Economic History Review*, n.s., 10, no. 2 (1957): 239–55.
- Temple, Richard, and Lavinia M. Anstey. *The Life of the Iclander Jón Ólafsson: Traveller to India*. Vol. 2. The Hakluyt Society 2, no. 68. London: Hakluyt Society, 1932.
- Toebosch, Theo. "'T Vliëgend Hert: Brieven aan Rex Cowan.'" In *Grondwerk: 200 Jaar archeologie in Nederland*, 129–48. Amsterdam: Uitgeverij SUN, 2003.
- Turner, Francis. "Money and Exchange Rates in 1632." n.d. Available at <http://1632.org/1632Slush/1632money.rtf>.
- Unger, Richard W. *Dutch Shipbuilding before 1800: Ships and Guilds*. Assen, the Netherlands: Van Gorcum, 1978.
- . "The Fluit: Specialist Cargo Vessels 1500 to 1650." In *Cogs, Caravels, and Galleons: The Sailing Ship 1000–1650*, edited by Robert Gardiner, 115–30. London: Conway Maritime Press, 1994.
- Unger, Willem S., ed. *De Oudste Reizen van de Zeeuwen naar Oost-Indië, 1598–1604*. De Linschoten-Vereeniging 51. The Hague: Martinus Nijhoff, 1948.
- Ure, Andrew. *A Dictionary of Arts, Manufactures, and Mines: Containing a Clear Exposition of Their Principles and Practice*. London: Longman, Brown, Greene and Longmans, 1846.
- Van Beylen, Jules. *Schepen van de Nederlanden: Van de late middeleeuwen tot het einde van de 17e eeuw*. Amsterdam: P. N. Van Kampen & Zoon, 1970.
- Van Daalen, Sjoerd, and Jelle van der Beek. "Dendroprovenancing Ship's Timbers: A Pilot Study on a Dutch 18th Century 'Ventjager.'" In *TRACE: Tree Rings in Archaeology, Climatology and Ecology*, edited by Esther Jansma, Achim Bräuning, Holger Gärtner, and Gerhard Schleser, 123–30. Vol. 2. *Proceedings of the Dendrosymposium 2003, 1–3 May 2003, Utrecht, the Netherlands*. Jülich, Germany: Forschungszentrum, Zentralbibliothek, 2004.
- Van Dam, Pieter. *Beschrijvinge van de Oostindische Compagnie*. Edited by Frederik W. Stapel. Vol. 1.1. Rijks geschiedkundige publicaten: Uitgegeven in opdracht van z. Exc. den minister van onderwijs, kunsten en wetenschappen, 63. The Hague: Martinus Nijhoff, 1927.
- Van de Moortel, Aleydis. *A Cog-like Vessel from the Netherlands*. Flevovericht 331. Lelystad, the Netherlands: Rijkswaterstaat, Directie Flevoland, 1991.
- Van den Broecke, Pieter. *Pieter van den Broecke in Azië*. Edited by W. Philippus Coolhaas. Vol. 1. De Linschoten-Vereeniging 63. The Hague: Martinus Nijhoff, 1962.
- Van der Heide, Geert J. "Reconstructie van een bijzondere Italiaanse trompet van de vindplaats Scheurak SO1." In *Vis en visvangst: Inleidingen gehouden tijdens het zevende Glavimans symposion, Vlaardingen, 23 april 1993*, edited by H. Reinder Reinders and Mette Bierma, 107–14. Groningen, the Netherlands: Glavimans Stichting, 1994.
- Van der Pijl-Ketel, Christine L., ed. *The Ceramic Load of the Witte Leeuw (1613)*. Amsterdam: Rijksmuseum, 1982.
- Van der Woude, Adrianus M. *Het Noorderkwartier: Een regionaal historisch onderzoek in de demografische en economische geschiedenis van westelijk Nederland van de late middeleeuwen tot het begin van de negentiende eeuw*. 3 vols. Afdeling Agrarische Geschiedenis Landbouwhogeschool. A. A. G. Bijdragen 16. Wageningen, the Netherlands: H. Veenman en Zonen, 1972.
- Van Dillen, Johannes G. *Bronnen tot de geschiedenis van het bedrijfsleven en het gildewezen van Amsterdam*. Vol. 2 (1612–32). Rijks geschiedkundige publicatiën: Uitgegeven in opdracht van z. Exc. den minister van onderwijs, kunsten en wetenschappen, 78. The Hague: Martinus Nijhoff, 1933.
- . *Bronnen tot de geschiedenis van het bedrijfsleven en het gildewezen van Amsterdam*. Vol. 3 (1633–72). Rijks geschiedkundige publicatiën: Uitgegeven in opdracht van de minister van onderwijs en wetenschappen, grote serie, 144. The Hague: Martinus Nijhoff, 1974.
- Van Duivenvoorde, Wendy. "Dutch Ministry of Finance Violates Agreement on Submerged Cultural Heritage." *INA Quarterly* 33, no. 1 (2006): 15–16.
- Van Foreest, Hendrik A., and A. de Booy. *De vierde schipvaart der Nederlanders naar Oost-Indië onder Jakob Wilkens and Jacob van Neck (1599–1604)*. Vol. 1. De Linschoten-Vereeniging 82. The Hague: Martinus Nijhoff, 1980.
- . *De vierde schipvaart der Nederlanders naar Oost-Indië onder Jakob Wilkens and Jacob van Neck (1599–1604)*. Vol. 2. De Linschoten-Vereeniging 83. The Hague: Martinus Nijhoff, 1981.
- Van Holk, André F. L. "Jaarringonderzoek van scheepsresten." Master's thesis, University of Groningen, Biological Archaeological Institute, 1986.
- . "Jaarringonderzoek van scheepsresten." In *Raakvlakken tussen scheepsarcheologie, maritime geschiedenis en scheepsbouwkunde: Inleidingen gehouden tijdens het Glavimans symposion 1985*, edited by H. Reinder Reinders, 75–81. Flevovericht 280. Lelystad, the Netherlands: Rijksdienst voor de IJsselmeerpolders, 1987.
- Van IJk, Cornelis. *De Nederlandsche scheeps-bouw-konst open gestelt: Vertoonende naar wat regel, of evenredenheyd, in Nederland meest alle schepen werden gebouwd; mitsgaders masten, zeylen, ankers, en touwen, enz. daar aan gepast: Soo uit de schriften van ouder, als jonger bouw-meesters, als ook by eygen ondervindinge, tot nut van alle jonge bouw-meesters, en*

- knechten, als ook uitreeders, en liefhebbers van scheepen*. Delft, the Netherlands: Andries Voorstad, 1697.
- Van Caerden, Paulus. "Kort verhael ofte Journael van de Reyse gedaen naer de Oost Indien met 4 schepen: *Nederlandt, Vereenigde Landen, Nassou, ende Hoff van Hollandt*, onder den Admiraal Pieter Both van Amesfort, voor Reeckeninge van de Nieuwe Brabantsche Compagnie tot Amsterdam: In den jaren 1599, 1600, ende 1601." Edited by Isaac Commelin. In *Begin ende Voortgangh van de Vereenigde Nederlantsche Geoctroyeerde Oost-Indische Compagnie*, book 2, vol 1, no. VI, 1–20.
- Van Linschoten, Jan H. *Reizen van Jan Huyghen van Linschoten naar het Noorden (1594–1595)*. Edited by Samuel P. L'Honoré Naber. De Linschoten-Vereeniging 8. The Hague: Martinus Nijhoff, 1914.
- Van Opstall, Margaretha E., ed. *De reis van de vloot van Pieter Willemsz Verhoeff naar Azië, 1607–1612*. Vol. 1. De Linschoten-Vereeniging 73. The Hague: Martinus Nijhoff, 1972.
- Van Rijn, Pauline. "The Analysis of Ten Wood Samples from VOC Shipwrecks *Batavia* and *Zeewijk*." BIAx Report 182, unpublished. Zaandam, the Netherlands: BIAx Consult, 2007.
- Van Spilbergen, Joris. *De reis van Joris van Spilbergen naar Ceylon, Atjeh en Bantam, 1601–1604*. De Linschoten-Vereeniging 38. The Hague: Martinus Nijhoff, 1933.
- . *De reis om de wereld van Joris van Spilbergen, 1614–1617*. Edited by Johan C. M. Warnsinck. De Linschoten-Vereeniging 47. The Hague: Martinus Nijhoff, 1943.
- Veluweekamp, Jan W. "Lading voor de Oostzee." In Daalder et al., *Goud uit graan*, 42–55.
- Verbiest, Anja, ed. "Batavia journaal." *Hollands Glorie* 1, no. 1 (Summer 1989): 35–38.
- Verken, Johann. *Molukken-Reise 1607–1612*. Edited by Samuel P. L'Honoré Naber. Vol. 2. Reisebeschreibungen von Deutschen Beamten und Kriegsleuten im Dienst der Niederländischen West- und Ost-Indischen Kompagnien 1602–1797. The Hague: Martinus Nijhoff, 1930.
- Voorbeijtel Cannenburg, Willem, ed. *De reis om de wereld van de Nassausche vloot, 1623–1626*. De Linschoten-Vereeniging 65. 1631. Reprint, The Hague: Martinus Nijhoff, 1964.
- Vos, Arent D. "De replica van een VOC-retourschip te Lelystad: De *Batavia*?" In *Bouwtraditie en scheepstype: Inleidingen gehouden tijdens het vierde Glavimans symposium*, edited by H. Reinder Reinders, 48–55. Groningen, the Netherlands: Universiteitsdrukkerij, 1991.
- Wagenaar, Lodewijk J. "Het eiland Onrust bij Batavia als onderdeel van het VOC-scheepsbedrijf in de 17de en 18de eeuw." *Antiek* 25, no. 2 (1990): 65–80.
- Wazny, Thomasz. "Aufbau und Anwendung der Dendrochronologie für Eichenholz in Polen." PhD diss., Universität Hamburg, 1990.
- . "Baltic Timber in Western Europe: An Exciting Dendrochronological Question." *Dendrochronologia* 20, no. 3 (2002): 1–8.
- . "The Origin, Assortments and Transport of Baltic Timber." In *Constructing Wooden Images: Proceedings of the Symposium on the Organization of Labour and Working Practices of Late Gothic Carved Altarpieces in the Low Countries, Brussels, 25–26 October 2002*, edited by Carl van de Velde, Hans Beeckman, Joris van Acker, and Frans Verhaeghe, 115–26. Brussels: VUB Press, 2006.
- Wegener Sleswyk, André. *De Gouden Eeuw van het fluitschip*. Franeker, the Netherlands: Van Wijnen, 2003.
- Werz, Bruno E. J. S. *Diving up the Human Past: Perspectives of Maritime Archaeology, with Specific Reference to Developments in South Africa until 1996*. BAR International Series 749. Oxford: J. and E. Hedges, 1999.
- . "Een bedroefd, en beclaaglijk ongeval": *De wrakken van de VOC-schepen Oosterland en Waddinxveen (1697) in de Tafelbaai*. Zutphen, the Netherlands: Walburg Pers, 2004.
- Witsen, Nicolaes. *Architectura navalis et regimen nauticum. Ofte Aaloude en hedendaagsche scheeps-bouw en bestier, waar in wydtloopigh wert verhandelt de wyze van scheeps-timmeren, zoo als de zelve eertydts by de Grieken, en Romeinen, in gebruik was: Scheeps-oeffeningen, stryden, tucht, wetten en gewoonten. Benefens evenmatige grootheden van de scheepen onzes tydts, ontleedt in alle hare delen: Verschil van bouwen tusschen verscheide landtaart: Indisch en Russisch vaar-tuigh: Galey-bouw, en hedendaagsche scheeps-plichten: Verrykt met een reeks verklaarde zeemans spreek-woorden en benaamingen*. Amsterdam: Pieter en Joan Blaeu, 1690. Original publication: Amsterdam: Casparus Commelijn, Broer en Jan Appelaer, 1671.
- Ypey, Jaap. "Wrak van een laat-zestiende-eeuws spiegeljacht." *Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek* 3, no. 1 (1952): 63–68.
- Zunde, Maris. "Timber Export from Old Riga and Its Impact on Dendrochronological Dating in Europe." *Dendrochronologia* 16–17 (1998–99): 119–30.

INDEX

NOTE: Page numbers in *italics* denote photographs, figures, or tables. Page numbers in **bold** denote maps.

- Abrolhos Islands. *See* Houtman Abrolhos Archipelago
- Academy of Fine Arts, Warsaw, 214–15
- acid deterioration, 43–44, 89
- Adams, Henry, 217
- adhesive used in reconstruction, 50
- adze marks. *See* tool marks
- Aeloude en Hedendaagsche Scheeps-bouw en Bestier* (Ancient and contemporary shipbuilding and management) (Witsen), 19–20
- Agamemnon* (ship), 217
- Allen, Greg, 3
- Amsterdam* (ship), 15, 38, 106, 157, 193, 200, 202
- Amsterdam, Netherlands. copper trade in, 121; shipbuilding in, 20–21, 27–28, 31, 32, 136–37; timber trade in, 10, 11–12, 73, 206–8, 215. *See also* Amsterdam Admiralty; Amsterdam Chamber
- Amsterdam Admiralty, 12, 16–17, 32, 143, 189
- Amsterdam Chamber, 1, 16, 20–21, 73–74, 79, 157–58, 183, 187, 193–94, 206–7
- Amsterdam foot, definition, 73
- anchorages abroad, VOC, 200–203
- Anglo-Dutch War, 218
- Angra C ship, 90, 147, 152–57, 216
- animal fibers in paying/caulking material. cattle hair, 105–6, 176; generic, 106, 151, 177, 187, 195, 237; goat hair, 97, 102–6, 107, 114, 119, 140, 176; wool, 105–6
- Anthonisz, Cornelis, 136
- Anthoniszoon map, 18, 136
- appraisals and inspections, 20–21, 38, 73–74
- archaeology of Dutch ships: Angra C ship, 90, 147, 152–57; *Avondster*, 147, 180–83; Barents's yacht, 147–49, 152; Christianshavn B&W 1 ship, 219; Christianshavn B&W 2, 147, 151–52, 227; Christianshavn B&W 5 ship, 219; conclusions, 184–85; dendrochronology, 218–20; late 1600s, 183–84; *Mauritius*, 38, 78, 147, 152, 157, 161–63, 182, 227; *Nassau*, 78, 146, 147, 157–61; overview, 143–47; Scheurrak S01 ship, 149–51, 219; Scheurrak T24 ship, 163, 219; *Vergulde Draak*, 147, 163–80; *Zierikzee*, 196–97. *See also* individual ships
- Arend* (yacht), 200
- artifacts of *Batavia*, overview, 4
- artwork, wood used in, 214–15, 216, 218, 221
- Asia trade, 15–16
- Assendelft* (ship), 1
- auctions of artifacts, 143, 146, 194
- Australia: *Batavia* site, 40–43; *Duifje* replica in, 220; Dutch exploration, 2; shipwreck ownership issues, 3–4; shipwrecks, 1–3, 163, 170, 172
- Autheunis, Lucas, 199–200
- AutoCAD, 67, 71, 72
- Avondster* (yacht), 147, 180–83, 185, 191, 195, 236
- Baker, Matthew, 22
- Baker, Patrick, 50, 56–57, 67
- Bakhuysen, Ludolf, 31, 32
- Baltic Sea region: Dutch trade in, 13–15, 215; wood (oak) imports from, 9–10, 206–8, 215–16. *See also* Vistula region wood sources
- Bantam* (ship), 187
- Barbour, Violet, 13
- Barents, William, 15, 146, 147–49
- Barents's yacht, 147–49, 152
- Batavia*: cannon on, 3, 40, 64, 77–79, 128; catalog of timbers, 253–63; conservation, 49–50; construction analyses, 73–74, 140–42, 224–34; deck configuration, 74, 76–77, 224, 231; dendrochronological research, 210–13; dimensions, overviews, 74, 224; excavation, 4, 47–51; formation of shipwreck site, 40–44; gun ports, 47, 77–79, 88, 93–94, 112, 124, 126–28, 231; iconography, 80; reconstruction and display, 57–63, 64, 65; recording of timbers, 50, 52–55, 55–57; sail/mast/rigging configurations, 75–76, 77; sinking of, 1–2, 40; site discovery, 3. *See also* individual timber/joinery types
- Batavia* (Jakarta), 1, 16, 18, 199–200
- Battle of Cape Rachado, 157–58, 161
- baye* wood, 204
- Beacon Island, 3, 50, 51
- belaying cleats, 130, 131
- Belgian timber trade, 215, 219
- bending wood, 30, 96–97, 139, 188, 204, 216, 220, 237
- Bessy (island), 204
- bilge planks/stringers, 30, 157, 191
- Blanchette, Robert, 139–40
- Blessing* (ship), 180–81
- blind treenails, 172
- Block, Adriaen Martenszoon, 36, 199
- boiling wood for bending, 270n 121
- Both, Pieter, 18, 158
- bottom-based ship construction: archaeological comparisons, 149, 151, 153, 170; *Batavia* analysis, 75, 142, 224–25; and carvel planking, 8–9, 38; and double planking, 192; master frames in, 22–27; and shape design, 21; transition to frame-based construction, 31, 34, 183–84, 191, 204; Witsen's manuscript on, 20, 27–31, 39
- bottom planking: construction analysis, *Batavia*, 109, 227–28, 233; construction analysis, general, 24, 26, 225; and teredo worms, 83, 102; and timber seasoning, 220
- Bound, Mensun, 159–60
- Boyarsky, Pyotr V., 147
- Brazil trade, 16–17

- Brouwer, Hendrik, 2
 Brouwer Route, 2
 brown rot, 139–40, 141, 221
 Bruker AXS Handheld XRF apparatus, 111
Buitenzorg (ship), 106, 170, 176, 189, 194, 195, 259
 bung, hawsehole, 98, 99
Buren (ship), 1
 Burlesdon ship, 189–90
 Burningham, Nick, 58
 Bushnell Edmund, 22
 BZN 10 shipwreck, 15
- cameras and equipment used, 54, 56–57, 67–68
 cannonballs, 110–11
 cannon on *Batavia*, 3, 40, 64, 77–79, 128.
 See also gun ports
 Cape Lopez, West African coast, 161
 Cape of Good Hope, 2, 15
 cardinal's hat, 98
 cargo capacity and size classification, 13, 17
 cargo floor of *Batavia*, 83, 110–12
 carpenters/craftsmen, scarcity of in
 Indies, 35–36, 198
 carvel planking, transition to, 8–9, 38, 188
 catalog of *Batavia* timbers, 253–63
 cathole, 98, 99
 cattle hair in paying/caulking material, 105–6, 176
 caulking materials, 105, 107
 ceiling planking: archaeological comparisons, 150, 155, 157, 157, 191–92, 229–30; wood species, 208–9
 ceiling planking of *Batavia*: description and construction analysis, 4, 46, 48, 85, 109–13, 128, 134–35, 229–30; extraction and raising of, 50; reassembly of, 60, 66, 83; in timber recording, 52–54; wood species, 79, 208, 210, 227
 Centro Nacional de Arqueologia Nautica e Subaquatica (CNANS), 152
 chaloupes, 36
 chambers (VOC), overviews, 11, 16
 charters (VOC), shipbuilding: 1603 charters, 241–45; 1614 charters, 245–46; 1616 charters, 246; 1653 charters, 246–47; merchant yacht, 249–50; overviews, 19–21, 39; return-voyage ship, 247–48; small yacht, 250–51; war yachts, 248–50
 Christianshavn B&W 1 ship; charred planking, 139; dendrochronology, 219; graving pieces, 90; as *verlanger*, 190, 191
 Christianshavn B&W 2 ship: archaeology overview, 151–52; ceiling planking, 112, 229; dendrochronology, 219; graving pieces, 90, 216; keel, 163; paying/caulking materials, 106; pine sheathing, 195; port of origin, 183; riders, 114, 182; sternpost, 227; treenails, 167
 Christianshavn B&W 5 ship, 219
 Christianshavn wrecks, overviews, 151–52, 213
 Christmas Fleet, 1
 Chronology II, 213
 clamps in construction, 28–29, 30
 classification scheme for timbers, 52–54.
 See also recording of *Batavia* timbers
 cleats in construction, 28, 29, 30, 89, 224
 clinker-build ship construction, 9
 Coen, Jan Pieterzoon, 35–36, 195, 200, 203, 204
 compass timbers, 206, 207, 208
Coninxberger trees, 37
 conservation and excavation, challenges to; acid deterioration, 43–44; incomplete/inconsistent records, 66–67; shape distortion, 63–64, 66; site conditions, 50, 63–64; tracings, 55, 57
 construction analyses of *Batavia*, overviews, 73–74, 140–42, 224–34
 construction records/plans: scarcity of for Dutch ships, 4, 5, 19, 21, 143, 183, 206.
 See also charters (VOC), shipbuilding; manuscripts, shipbuilding
 copper sheathing: archaeological comparisons, 152, 160, 176–80, 193–94, 197; chemical analysis and provenance, 119, 121–24, 180
 copper sheathing of *Batavia*, 114, 119–24, 120, 136
 copper tacks, 119, 120, 121, 123. *See also* copper sheathing
 Cornelisz, Jeronimus, 3
 Corneliszoon, Adriaen, 12
 Corneliszoon, Cornelis, 10, 38
 costs of ship construction/repairs: flutes, 13, 14–15; in Indies, 35, 36, 38; lead/copper sheathing, 193; paying materials, 106, 194, 195; replanking/sheathing, 203–4, 280–81n 39; and standardization, 13–14; VOC Indiamen, 37–38; wood, 206
 costs of ships purchased, 161, 163
 Cramer, Max and Graham, 3
 Crescentius, Bartholomeus, 26
 crew sizes, 2–3, 15, 27
 Crisman, Kevin, 152
 curing of wood, 220–22
- Dassié, F., 26
 deadwood, 155
 deck configurations: *Batavia*, 74, 76–77, 224, 231; VOC ships, 4, 13, 14, 17, 18, 21, 158
 deck timbers and construction: *Batavia*, 53, 110, 130–34, 232–33; ships, 20, 30–31, 37
 deforestation, 202–3, 216–17
 dehumidification, 49, 59
Delft (ship), 200
 Delft Chamber, 16
 dendrochronology of timbers, 210–13, 218–20, 265–66
De Nederlandsche Scheepsbouw Konst Opengesteld (The art of Dutch shipbuilding exposed) (Van IJk), 20
 depth of *Batavia* wreck, 3, 40
 De Rat sawmill, 173–75
 desalination of timbers, 49, 164
 De With, Witte Corneliszoon, 200
 Direction des Recherches Archeologiques Sous-Marines (DRASM), 161
Dolfijn (ship), 183, 184
Dordrecht (ship), 1, 76, 202
 double planking: archaeological comparisons, 147, 149–50, 151, 153, 160, 161, 168, 170, 181; *Batavia*, 66, 80–86, 94; history of and construction analyses, 146, 186–93, 204–5; pine sheathing, 86, 88, 101, 187
 double rabbets, 150, 163, 227
 dovetail joints, 125, 155, 227
 draft marks, 117–19

- Drake-Brockman, Henrietta, 3
drawing of timbers. *See* tracing of timbers
Drok, Evert D., 3
drop strakes, 84
drying/curing of timbers, 49–50, 220–22
dry rot, 139–40, 141, 194, 221
Dubbele Arend (ship), 77
dubbeling. *See* double planking; pine sheathing
Duijfe (replica), 220
Duijfe (ship), 2, 29, 217
Durão, António, 196
Dutch shipbuilding tradition: *Batavia*
study conclusions, 235–39; fifteenth century ship construction, 8–9; lap-strake to carvel planking, evolution of, 8–9; manuscripts, shipbuilding, 19–22; seventeenth century ship construction, 21–22; VOC charter specifications, 73–74, 224. *See also* archaeology of Dutch ships; bottom-based ship construction; charters (VOC), shipbuilding; double planking; frame-based ship construction; Van IJk, Cornelis; Witsen, Nicolaes
Dutch United East India Company (Verenigde Oostindische Compagnie, VOC). *See* VOC (Dutch United East India Company (Verenigde Oostindische Compagnie))
Easter Fleet, 1
Easter Group of islands, 40, 41
EDAX analysis, 122, 180
Edwards, Hugh, 3
Eendracht (ship), 36, 187, 200
Elf-Gabon company, 161
elm wood, 181
English Channel, 2
English East India Company, 180–81
The English Factories in India, 181
English shipbuilding and trade: architecture and standardization, 12, 22, 226–27; and Brouwer Route, 2; English East India Company ships, 180–81; multiple planking, 189–90; trade goods, 215
Enkhuizen Chamber, 1, 16, 206
Erasmus (ship), 157
Evertssen, Tobias, 207
excavation of *Batavia*: challenges to, 43–44, 50, 55, 57, 63–64, 66–67; extraction and raising of timbers, 50–51, 52–53; overview, 4
exportation of ships, 9
extraction and raising of timbers, 50–51
Fair Fleet, 1–2
fashion piece of *Batavia*: description and construction analysis, 124–26, 227; extraction and raising of, 50–51; hull planking joinery, 85; steel backing plate for, 59, 62; and transom assembly, 53; transom planking joinery, 97
fastenings, overview of findings, 134–36. *See also* joinery
felt, 273*n* 43. *See also* animal fibers in paying/caulking material
field number assignment and tagging, 47–48, 52–54
filling nails, 100–102, 136, 166, 168, 170, 173, 181
filling strakes, 231–32
fire, onboard, 158, 201
fire-shaping of planks, 30, 139, 220
fir wood, 10, 195–96. *also* pine wood
flat-floored ships, 74–75
flat transoms, 4, 18–19, 39, 74
floor planking: archaeological comparisons, 154–55, 156; of *Batavia*, 83, 110–13, 111, 228–29
flush-laid planks. *See* carvel planking, transition to
flute ships, 13–15, 39, 189, 215
forecastle, presence of, 158
Fournier, Georges, 23, 26
frame-based ship construction, 32: English and French standardization of, 21–22; overview of techniques, 8–9, 225; transition to, 31, 34, 183–84, 191, 204, 222–23; Van IJk's manuscript on, 20, 32–34, 39
framed pit saw, 136–38
frame timbers, archaeological comparisons, 166, 168, 172, 181–82
frame timbers of *Batavia*, 46, 48; description and construction analyses, 107–9, 225; extraction and raising of, 50–51; timber classification scheme, 52
frame wales, 230–31
framework, support. *See* support strategies for display
Fransz, Adriaen, 158
Frederik Hendrik (ship), 76
Fremantle (Australia), 49, 57. *See also* Western Australian Museum
French shipbuilding and trade, 8, 12, 21–22, 215
Friel, Ian, 190
Friesland (ship), 202
fungus, wood, 57, 221
Furttenbach, Joseph, 26
futtocks: archaeological comparisons, 155, 161, 228–29; in bottom-based construction, 30–31, 75, 225
futtocks of *Batavia*, 107–9
Galiasse (ship), 76
galleon type, 4–5
garboard strake construction, 27–28, 32, 163, 227–28
Gelderland (ship), 202
Gentlemen XVII, 16
German wood sources, 10, 206–8, 216, 219
Geünieerde Provinciën (ship), 157
glass (ground) in plank coatings, 106, 151
goat hair in paying/caulking material, 97, 102–6, 107, 114, 119, 140, 176
The Good Ship (Friel), 190
Grace Dieu (ship), 189–90
Graveney boat, 190
's-Gravenhage (ship), 1, 73, 74
graving pieces, 90–93, 141, 216, 222
The Great Circle (Marquardt), 18
Green, Jeremy, 4, 50, 163
green wood, 220–21, 222
Griffioen (yacht), 18, 186, 196, 200, 201
Grote Maan (ship), 189
Grote Zon (ship), 157, 189
gudgeons, rudder, 97, 114, 115, 117
guilds, 11–12, 15, 136
gun ports: of *Batavia*, 47, 77–79, 88, 93–94, 112, 124, 126–28, 231; construction and placement standards, 30, 34, 77–79. *See also* cannon on *Batavia*
“half-worn” classification, 38
hand-sawn planks, evidence of, 136

- hanging deck knees, 53, 88, 114, 130–32, 232
harpuis, 186, 194
 Hawkins, Richard, 158, 188, 193
 heartwood vs. sapwood, 213
 heat bending wood, 30, 97, 139, 220, 270*n* 121
 heeling over, 198–99, 201
 Hein, Piet, 194
Hercules (ship), 183, 184, 187, 193
 Heren XVII, 16
 Heyn, Piet, 143, 202
 hinges, gun port, 93–94, 128
 Hocker, Frederick M., 9, 188, 191
Hof van Holland (ship), 158
 Holland, map of, 11
Hollandia (ship), 76, 194, 200, 201–2
Hollandse Tuin (ship), 16–17, 187
Hoop (yacht), 18–19, 200
 Hoorn Chamber, 1, 16
 horse hair in paying/caulking material, 105, 273*n* 44, 274*n* 51
 Houtman, Cornelis, 15
 Houtman Abrolhos Archipelago, 1, 3, 40, 41, 43
 Hoving, Ab J., 24, 26, 192
 hull coatings. *See* animal fibers in paying/caulking material; resinous coating/paying materials
 hull curvature/shape: bottom- vs. frame-based construction, 24–26, 28, 32, 34, 39; seventeenth century architecture, 21–22; transom assembly, 127. *See also* bending wood
 hull curvature/shape of *Batavia*, 63–64, 63–66, 68–72, 74–79
 hull planking: archaeological comparisons, 147–49, 152, 153–54, 161, 162, 164, 166–72, 181; construction methods, 28; extraction and raising of, 51. *See also* thickness/width of planking
 hull planking of *Batavia*: description and construction analysis, 80–89; extraction and raising of, 50; inner layer, 45, 48, 52, 54, 81, 82; outer layer, 45, 82, 83; reassembly and display, 61–63; in timber classification scheme, 52. *See also* ceiling planking of *Batavia*; thickness/width of planking of *Batavia*
 hull structure/timbers of *Batavia*: author's study, overviews and methodology, 4, 67–69, 79–80; construction analysis, 224–34; overview of discovery, 44–47. *See also* hull planking of *Batavia*
 Hundley, Paul, 57–58
Hydrographie (Fournier), 26
 iconographic evidence, 5, 18–19, 75–78, 136–37
 India, ship repairs in, 199
 in situ observations/recording, 5, 50, 52–55
 inspections and appraisals, VOC, 20–21, 38, 73–74
 Institute for Wood Biology, University of Hamburg, 214–15
 inter-continental trade, early Dutch forays, 15–16
 intra-Asiatic trade, 17–18, 36
 intra-European trade, 13–17
 iron bolt joinery, 115, 135, 151, 172–73, 227
 iron corrosion and concretion, 43–44
 iron oxide layer and protection from marine organisms, 101, 180, 188, 195, 196, 205
 iron spike joinery: archaeological comparisons, 151–52, 161; frame timbers, 109, 110; gudgeons, 115; gun port and lid, 93–94; hull planking, 85–86, 134–35; kevel, 130; overview, 134–35; transom planking, 94, 97
 Italian shipbuilding, influence of, 22
Jager (yacht), 198
 Jakarta. *See* *Batavia* (Jakarta)
 Jansz, Hendrik, 198
 Jansz, Willem, 2
 Japan, ship repairs in, 36, 203
 Japara, Java, 203
 Java, 203
 Jellema, Simon, 173, 175
John and Thomas (ship), 180
 Johnson, Dave, 3
 joinery: dovetails, 125, 155, 227; filling nails, 100–102, 136, 166, 168, 170, 173, 181; iron bolts, 115, 135, 151, 172–73, 227; mortises, 89, 97, 117, 155; scarfs, 84–85, 94, 110, 153. *See also* iron bolt joinery; treenails
 joint-stock companies (*voorcompagnieën*), 15
kardinaalsmuts, 98
karveels, 8
 Kasi, Kalle, 111
 keels, archaeological comparisons, 149, 150, 151, 153, 154, 163, 195, 197, 227
 keelsons, 24, 155, 156
 keel strake, 27
keilgang (garboard strake), 27–28
Kennermerland (ship), 183, 184
 kettle bottomed hull form, 13
 kevel, 130, 131
 Kimpton, Geoff, 57–58, 59–60, 66, 67
 Kingma, Vibeke, 12
Kleine David (ship), 1
Kleine Zon (ship), 157, 158
 knees: hanging deck knees, 53, 88, 114, 130–32, 232; transom knees, 52–53, 128, 130, 232. *See also* lodging knees
 knots in wood, 216. *See also* graving pieces
Koning David (yacht), 200
 Kravtsjenko, Dimitri, 147
 lapstrake vs. carvel planking in bottom-based construction, 8–9
 Larn, Richard and Bridget, 183
Lastdrager (ship), 183
 laths, floor support, 110, 111, 112
 lead isotope analysis of copper sheathing, 121–24
 lead sheathing, 112, 160, 161, 178–80, 187, 193–94, 197, 205
 legislation protecting shipwrecks, Australian, 3–4
Leiden (ship), 76, 198
Lelie (ship), 183, 184
 Le Maire, Jacob, 187
 Lemée, Christian P. P., 151, 191, 273*n* 43
 lengthening of ships, 13, 39, 190–91
 length-to-beam ratios, 13, 74, 224, 235
 Leonard, Bill, 68–69, 70, 220, 222
 L'Hermite de Jonge, Jacques, 158, 200–201
 Liorne, Pieter Jansz, 13, 20, 191
 lodging knees: description and construction analysis, 128, 130, 131, 132–33, 232–33; excavation of, 52–53; and seasoning of wood, 220
 looting, complications/losses from, 5, 143

- Maan* (ship), 199
 Maarleveld, Thijs, 145
 Madrague de Giens ship, 189
 main frame construction, 32–34
 Malacca, attack on, 157–58, 161
 manuscripts, shipbuilding, 19–22. *See also*
 Van IJk, Cornelis; Witsen, Nicolaes
Mariner's Mirror, 217
 Marquardt, Karl, 18
 master frames in bottom-based construction, 22–27, 30, 31
 mast/sail/rigging configurations, 5, 15,
 75–76, 77
 Mataram, Java, 203
 Matelief de Jong, Cornelius, 78, 157–58
Mauritius (ship), 38, 78, 147, 152, 157, 161–
 63, 182, 183, 188–89, 200; keel, 227; lead
 sheathing, 1936; repairs to, 201
Mauritius (island), Dutch post on, 201–3
 May, Jan Corneliszoon, 36
 May, William, 194
 mechanically sawn planks, evidence of,
 152, 175
 Mediterranean shipbuilding, influence of,
 8–9, 12, 22, 31, 189
Middelburg (ship), 157, 158, 159
 Middleburg Chamber. *See* Zeeland
 (Middleburg) Chamber
 midships molds, 21, 22, 23, 39
 Miller, Thomas, 26
 models of *Batavia* hull, 57–58
 mold frames, 8–9, 21–22, 96–97. *See*
 also master frames in bottom-based
 construction
 Monte Cristi ship, 106
Morgenster (ship), 187
 Morning Reef, 2–3, 40, 42
 mortise joinery, 89, 97, 117, 155
 moss-like material in paying/caulking,
 104, 105
 multilayer planking, 225. *See also* double
 planking
 Murray, Christian, 181, 182
 Myers, Maggie, 165

 nail holes, 86, 87, 101. *See also* nailing pat-
 terns; nail plugs
 nailing patterns: gun port lid, 93; hull
 planking, 86, 135; pine sheathing, 100–
 102, 119, 136; quincunx, 93, 101, 119, 136,
 166, 181, 195
 nail plugs, 28, 75, 86, 89–90, 152, 167–68,
 171, 224–25
Nassau (ship), 78, 146, 147, 157–61, 183, 189,
 193, 194
 Nassau Fleet, 200–201
National Geographic Magazine, 146
 nautical archaeology, development of, 183
 Nautical Archaeology Program of Texas
 A&M University, 152
Nederland (ship), 158
Nederlandsche scheeps-bouw-konst open
 gesteld (Van IJk), 32–34
 Nederlands Instituut voor Scheeps-en
 onderwater Archeologie, 149
 “new” classification, 38
 Nieuwe Brabantse Company, 158
Nieuw Rhoon (ship), 189
 Nikkor lenses, 54
 Nikon cameras, 56, 57
 Nikonos cameras, 54
 Nikon Super Coolscan 4000 ED, 67
 NLARTP01 chronology, 212, 213–15, 219
 NLPP chronology, 213
 Noon Reef, 3
 Noorderkwartier region, 31, 73, 153, 183
 North Island, 40, 41
 Norway, wood imports from, 10
 Nova Zembla (Novaya Zemlya), Russia,
 147

 oak wood: artwork use, 214–15, 216; den-
 drochronology, 211–13; hull planking,
 152, 186–87, 196; import sources for,
 9–10, 206–8, 215–19; species identifica-
 tion, 164, 169, 208–10; structural tim-
 bers, 4; treenail manufacture, 166–67;
 VOC charter specifications for, 20–21.
 See also double planking
 “old” classification, 38
 Oliveira, Fernando, 26
 Onrust island, 36, 37, 200, 204
Oosterland (ship), 183–84
 Open Polar Sea route, 15, 18, 147
Oranje (ship), 157, 200

pantchialing (boats), 36
Parel (ship), 77, 79

 Parthesius, Robert, 180–81
 paying materials, 106–7, 194–95
 pegs: nail hole, 28, 75, 86, 224–25; treenail,
 85, 86, 134, 151, 167, 170, 172, 230
 Pelsaert, Francisco, 3, 40, 43, 77, 79, 80, 81
 Pelsaert Group of islands, 40, 41
 Phaneuf, Eric, 153
 photography of timbers, 50, 54, 55–56,
 56–57
 Photoshop (Adobe), 68
 Piet Bas map, 18
pinas (warship), 27
pinasen/pinnaces/pinances, 17
 pine sheathing: archaeological compari-
 sons, 149, 151, 157, 161, 164, 167, 173, 181;
 filling nails used for, 100–102, 136,
 166, 168, 170, 173, 181; history of and
 construction analyses, 195–96, 197;
 protection from teredo worms, 180,
 186, 187–88, 195–96. *See also* pine
 wood
 pine sheathing of *Batavia*: description
 and construction analysis, 99–102,
 233–34; double layered, 86, 88, 101,
 187; excavation of, 52; overviews, 79;
 reconstruction plan, 83; sternpost, 114,
 117–19; on transom planking, 53. *See*
 also pine wood
 pine wood: dendrochronology, 211–
 13; floor planking, 111, 112; in flute
 construction, 15; import sources, 10,
 206–8; species identification, 164, 169,
 208–10, 211; VOC charter specifica-
 tions for, 20. *See also* pine sheathing
Pinksterbloem (ship), 201
Pinus sp. *See* pine wood
 pitch in coating/paying materials, 194–95.
 See also resinous coating/paying
 materials
 plain/tangential sawing, 213, 214
 planking-first construction. *See* bottom-
 based ship construction
 planking rot, 139–40, 141, 194, 221
 planking strakes of *Batavia*. *See* hull
 planking of *Batavia*
 Polish wood sources, 206–8, 213–16, 218,
 219
 polyethylene glycol (PEG), 49
 Porsius, Nanning, 206

- Portuguese shipbuilding and trade: control of Asia trade, 2, 15; Dutch conflicts with, 1, 17, 146, 157–58, 161, 196; India-men comparison, 4, 16; lead sheathing on, 193; shipbuilding techniques, 8
- Prexiso laser distance meter, 69–70, 71
- Prinses Maria* (ship), 183
- Prins Willem* (ship), 79
- Pulau Kapal island, 200
- purchased ships, 34, 38, 161, 163
- quarterdeck, presence of, 158
- quarter sawing, 213
- Quercus* sp. *See* oak wood
- quincunx nailing patterns, 93, 101, 119, 136, 166, 181, 195
- rabbet line, 115
- radial sawing, 213
- raising of timbers, 50–51
- rake, sternpost, 226–27
- Raleigh, Sir Walter, 15
- recording of *Batavia* timbers, 50, 52–55, 55–57, 253–63
- refitting ships, 13, 34, 38, 161, 186–87, 193. *See also* lengthening of ships; replanking; resheathing
- The Renaissance Shipwrecks from Christianshavn* (Lemée), 151
- repairs. *See* replanking; resheathing
- replanking, 152, 195, 197–200, 201–4
- Research and Consultancy Service for Biological Archaeology and Environmental Reconstruction, 102–3
- resheathing, 158, 187, 195, 197–200, 201–4
- resinous coating/paying materials, 106–7, 151, 186, 194–95, 197
- retourschepen*, 17
- return-voyage ships, 17, 247–48
- Rhine region wood sources, 10, 206–8, 215
- ribbands, 30–31, 34
- Richards, Vicki, 111
- riders, 114, 135, 152, 182, 232
- rigging configurations, 5, 15, 75–76, 77
- Rijksen, Jan, 20, 21, 22, 24, 73, 210–11, 224
- Rijp, Jan Corneliszoon, 147
- Roaring Forties (winds), 2
- Roe, Thomas, 199
- Rooswijk* (ship), 145
- rot, 139–40, 141, 194, 221
- Rotterdam* (ship), 199
- Rotterdam Chamber, 16
- round tuck sterns, 14, 18
- rudder gudgeons, 97, 114, 115, 117
- rudders, 160, 193
- Russian Research Institute of Cultural and Natural Heritage, 147
- rust layer and protection from marine organisms, 101, 180, 188, 195, 196, 205
- Ryder, Michael, 105
- Salamander* (ship), 76, 79
- salvage (commercial) losses, 5, 143, 145–46, 194
- sapwood vs. heartwood, 213
- saw marks. *See* tool marks
- Sawmill Development Company, 12
- sawmills, wind-driven: and cost efficiency, 14; De Rat sawmill, 173–75; vs. hand sawing, 136–37; invention of, 10–12, 38; machine sawn planks, evidence of, 152, 173–75
- sawn wood vs. logs, imported, 215
- sawyers guilds, 11–12, 15, 136
- Scandinavian wood sources, 9–10, 206–8, 215
- scarf joints (planks), 84–85, 94, 110, 153
- SCH1115M chronology, 213
- Schapendam, Huygen, 200–201
- scheergang*, 229
- scheerstrook* (sheer strake), 30, 229
- Scheurrak So1 ship, 147, 149–51, 182, 188, 219, 227, 229
- Scheurrak T24 ship, 163, 219
- Schillemans, Cornelis, 207
- Schouten, Willem Corneliszoon, 187
- seasoning of wood, 220–22
- Sebessy (island), 204
- secrecy around shipbuilding techniques, 21, 35
- 's-Gravenhage (ship), 1, 73, 74
- shape/configuration: bottom- vs. frame-based construction, 24–26, 28, 32, 34, 39; Dutch ships, 4–5, 18, 75–76; flutes, 13; hull curvature/shape of *Batavia*, 63–64, 63–66, 68–72, 74–79; hull design seventeenth century, 21–22; transoms, 4, 17, 18–19, 39, 74, 127. *See also* deck configurations
- sheer line, 34
- sheer strake, 30, 34
- shelf clamps, 52, 110, 131, 232
- shell-based ship construction, 8–9, 82, 85, 188, 189–90
- shipwrecks, VOC, 1–4. *See also* archaeology of Dutch ships
- shoring poles in construction, 30
- shrinkage of wood in conservation, 66
- Sierra Leone, 200–201
- single layer hull planking, 168, 170
- sloops, 36
- soft rot of hull planking, 139–40
- South African Institute of Maritime Archaeology, 183
- Southern Group of islands, 40
- Spanish shipbuilding and trade, 16, 158, 200–201, 202
- spant berghouten* (frame wales), 230–31
- spijkerpennen* (nail plugs), 28, 89–90, 153
- square tuck sterns, 14, 17, 18–19
- Sri Lankan Maritime Archaeology Unit, 181
- standardization and shipbuilding efficiency, 13–14
- Standvastigheid* (ship), 35, 38
- Steffy, J. Richard, 143
- Sténuit, Robert, 146, 183
- sternposts: archaeological comparisons, 27, 152, 176–80, 194; of *Batavia*, 95, 97, 114–19, 120, 225–27. *See also* copper sheathing
- stern shapes, 13, 14
- strengthening, strategies for, 189
- subfloor planking, 112
- sulfur in coating/paying materials, 106–7, 186, 194–95
- Sunda Strait, 2
- support strategies for display, 59–63, 64
- Swedish copper, 121–24
- Swedish-Polish War, 218
- tagging of timbers, 52–54, 67
- tangential sawing, 213, 214
- teak wood, 204
- teeth per stroke, 173, 175
- teredo worms. *See* worms, teredo

- Texel, Netherlands, 1, 157
- thickness/width of planking, 188–89, 190–91, 227–28
- thickness/width of planking of *Batavia*: ceiling planks, 109–10, 135, 230; deck timbers, 232–33; filling strakes, 231–32; floor planks, 110; hull planks, 80–84, 86, 189; pine sheathing, 99, 100; stern-post planks, 117; transom planks, 94, 97
- Thirty Years War, 217–18
- thumb, definition, 73
- timber plans of *Batavia*: ceiling planking, 110; creating, 55–56, 67; frame, 107; hull planking, 81, 82; pine floors, 111; pine sheathing, 100; and reconstruction, 59, 68
- timber trade, overviews, 9–10, 206–8, 215, 222–23. *See also* sawmills, wind-driven; wood usage
- tool marks, 96, 98, 119, 136–38, 173–75
- Toyo cameras, 57
- tracheids, wood, 208
- tracing of timbers, 55–56, 57, 66–68
- trade, overviews, 13–17. *See also* timber trade, overviews
- Transea Sdn Bhd company, 159
- transom assembly of *Batavia*, 49: description and construction analysis, 124, 125, 227, 228; gun port, 126–28; reassembly and display of, 60–61; in situ, 126; standing knee, 128; in timber classification scheme, 52–53; wing transom, 124, 126–28. *See also* fashion piece of *Batavia*
- transom beams of *Batavia*, 128, 129
- transom configurations, 4, 17, 18–19, 39, 74, 127
- transom knees, 52–53, 128, 130, 232
- transom planking of *Batavia*, 54, 94–98, 99, 232
- treasure hunting, complications/losses from, 5, 143, 145
- Treatise on Shipbuilding*, 226–27
- treenails: archaeological comparisons, 149–50, 151, 153–54, 155, 161, 166–67, 170, 172, 180, 184, 191; *Batavia* construction analysis, 228–29, 230; frames and planking, 85, 86, 109, 134; manufacture of, 166–67
- trees: availability of, 36–37; number used in ship construction, 190, 217; over-harvesting and deforestation, 202–3, 216–17. *See also* wood usage
- Trial* (ship), 2
- triple planking, 189–90
- tuck shapes, 13, 14–15
- turret built hull form, 13
- Twikkelo* (ship), 34
- tyloses, 209, 275*n* 92
- Unger, Richard, 13
- The Unlucky Voyage (Ongeluckige voyagie)* (Pelsaert), 77, 79, 80, 81
- Utrecht* (ship), 76, 202
- Van Caerden, Paulus, 16–17, 158, 187, 196
- Van Dam, Pieter, 20, 34–35, 207–8, 209, 213
- Van den Broecke, Pieter, 36, 75, 76
- Van Doorninck, Frederick, 143
- Van Elburg, Albert, 207
- Van Haaster, Henk, 103
- Van Haghen, Willem, 198
- Van Heemskerck, Jacob, 15, 147, 198–99
- Van Holk, André, 219
- Van IJk, Cornelis: on animal hair applications, 106; on bottom-based construction, 31; on coating/paying materials, 194; on copper sheathing, 194; on costs of shipbuilding, 37; on double planking, 191–92; on frame-based construction, 191; on green vs. seasoned wood, 220–21; on hull planking thickness, 188–89; manuscript on shipbuilding, 20, 32–34, 39; on pine sheathing, 233–34; on timber, 207–8; on transom planking, 94, 96–97
- Van Linschoten, Jan Huygen, 15, 195–96
- Van Nassau, Maurice, 202
- Van Neck, Jacob Corneliszoon, 16
- Van Noort, Oliver, 19, 193
- Van Rosingeyn, Jan Lodewijksz, 2
- Van Spilbergen, Joris, 198
- Van Warwijck, Wybrand, 158, 161
- Van Zwijndregt, Paulus, 34
- Venetian shipbuilding, influence of, 22, 23
- ventjager*, 218–19
- verdubbeling*. *See* double planking; pine sheathing
- Verenigde Landen* (ship), 158
- Vergulde Draak* (ship), 2, 106, 147, 163–80, 183, 184, 189, 191; copper sheathing, 194
- Vergulde Zeepaard* (ship), 76
- verlangers*, 13, 39, 190–91
- Vistula region wood sources, 213, 215–16, 216–18, 219. *See also* Polish wood sources
- VOC (Dutch United East India Company (Verenigde Oostindische Compagnie)): early trade forays, 16–19; founding of, 16; shipbuilding/repairs in Indies, 34–37, 197–200; shipyards in Netherlands, 34. *See also* charters (VOC), shipbuilding; Dutch shipbuilding tradition
- volume of *Batavia*, 74
- voorcompagnieën*, 16, 146
- Vos, Arent, 188, 192
- Wadden Sea, 149
- Waddinxveen* (ship), 183–84
- wales, 88, 197, 225, 230–31
- Wallabi Group of islands, 40, 41
- Wallabi Islands, 3
- Wapen van Delft* (ship), 76
- Wapen van Rotterdam* (ship), 76
- warships: charters for, 248–50; frame-based construction, 31, 32, 34; hull planking on, 189, 190, 193; iconography, 17; *Overijssel*, 201; shell-based construction, 189; transom shape, 18; volume of timber used in, 217; Witsen on shape and construction, 27, 28
- Warwijck, Wybrand, 202
- watering of wood, 221–22
- waterline markings, 117–19, 226
- waterproofing techniques, 97, 188, 192, 195. *See also* paying materials
- waterways, lower deck, 131, 133, 232
- wax in waterproofing, 195
- wedges: for futtocks, 109; for transom knees, 130, 131; treenail, 85, 154, 172, 228
- Wegener Sleswyk, André, 13–15, 191
- weights, ship: Dutch-built exports, 9; Dutch Indiamen, 4, 16; Portuguese ships, 16

- Wells, John, 22
- Werz, Bruno, 183–84
- Western Australian Museum, 4, 44
- West India Company (WIC) and saw-mills, 12
- whale oil in paying materials, 194
- whaling ships and double planking, 192
- width of planking. *See* thickness/width of planking
- Windhond* (yacht), 200–201
- winds: Southeast Trade Winds, 2; westerly (Roaring Forties), 2
- wing transom, 124, 126–28
- Witsen, Nicolaes: on angled garboard strakes, 163; on animal hair applications, 106; on Baltic oak, 216; bottom-based construction described by, 27–31, 39; on coating/paying materials, 194; on costs of shipbuilding, 37; on green vs. seasoned wood, 220–21; on hull planking thickness, 188–89; on lead sheathing, 193–94; manuscript on shipbuilding, 19–20, 26–27; on master frames, 24, 26; on sternpost construction, 225, 226; on timber, 207–8; on watering of wood, 221–22
- Witte Leeuw* (ship), 38, 78, 146, 157, 161
- wood usage: dendrochronological research, 210–13; drying/seasoning timbers, 49–50, 220–22; planking manufacture, 213; provenance, 213–16; resources in Indies, 203–4; scouting for appropriate sources, 36–37; species identification, 164, 169, 208–10, 211; timber, importing of, 9–10, 13–14, 206–8, 215; VOC charter specifications for, 20–21; volume of timber used in ship construction, 9–10, 190, 217–18; worm resistance, 37. *See also* oak wood; pine wood
- wool in caulking material, 105–6
- worms, teredo: coating/paying material protection from, 102, 140, 194–95; copper sheathing protection from, 194; iron oxide layer and protection from marine organisms, 101, 180, 188, 195, 196, 205; pine sheathing protection from, 180, 186, 187–88, 195–96; wood resistance to, 37
- yachts: Barents's, 147–49; charters for, 248–51; definitions, 17, 18; in inter-Asiatic trade, 17–18; transom configurations, 18–19
- Zaandam: shipyards, 9, 31, 183; timber trade in, 11, 207, 215, 223
- Zaandam* (ship), 1
- Zaan region, 11, 12, 13
- Zeeland* (ship), 202
- Zeeland (Middleburg) Chamber, 16, 21, 73, 74, 206, 207
- Zeewijk* (ship), 2, 176
- Zierikzee* (ship), 196
- Zon* (ship), 193, 199
- Zuiddorp* (ship), 2, 170, 172
- Zuid Holland* (ship), 36
- Zwaan* (yacht), 18, 186
- Zwarte Leeuw* (ship), 157, 198–99



Eight months into its maiden voyage to the Indies, the Dutch East India Company's *Batavia* sank on June 4, 1629, on Morning Reef in the Houtman Abrolhos off the western coast of Australia. The vessel was lost, and the ship's story became notorious for a mutiny and horrific massacre among the shipwreck survivors. Little mention was made of the wreck site until it was discovered by a local fisherman in 1963 and excavated several years later by a team of archaeologists from the Western Australian Museum.

The wreck of the *Batavia* and its associated land features have become one of Australia's most prominent archaeological heritage sites. A significant part of the hull has been reassembled and is displayed in the Shipwreck Galleries of the Western Australian Museum. However, although the site is well-known and many articles and books have described *Batavia*'s history and archaeological remains, the study of *Batavia*'s construction and wooden hull has remained unpublished until now. The Dutch shipping industry was the foremost in the world throughout the seventeenth century, but has received only cursory scholarly attention because it was assumed that not enough source material survived to complete a thorough study. Wendy van Duivenvoorde's five-year study was aimed at reconstructing the hull of *Batavia*, the only excavated remains of an early seventeenth-century Indiaman to have been raised and conserved in a way that permits detailed examination, using data retrieved from the archaeological remains, interpreted in the light of company archives, ship journals, and Dutch texts on shipbuilding of this period.

In addition to the historical and socio-economic information in the site report, the author emphasizes the technological parameters and thought processes represented in the production of the hull and related elements. The systematic and analytical approach includes detailed aspects of metallurgy, casting techniques, and woodworking for shipbuilding, allowing the ship to be interpreted in relation to what is known about the people who built and sailed it, their understanding and objectives, and the technology available at the time of its construction. Over two hundred tables, charts, drawings, and photographs are included. In this context, *Dutch East India Company Shipbuilding: The Archaeological Study of Batavia and Other Seventeenth-Century VOC Ships* goes beyond coverage of the *Batavia* shipwreck to provide the only written analysis to date of Dutch oceangoing ship construction in the first half of the seventeenth century.

WENDY VAN DUIVENVOORDE is a lecturer in maritime archaeology at Flinders University and deputy director of the Australian Consortium of Humanities Research Centres. She is also affiliated faculty with the Institute of Nautical Archaeology at Texas A&M University.

Texas A&M University Press
College Station
www.tamupress.com